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ORIGINAL ARTICLES.

I.—Note on a Mounted Skeleton of *Myotragus balearicus*, Bate.

By C. W. Andrews, D.Sc., F.R.S. (British Museum, Nat. Hist.).

(PLATE XII.)

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In the volume of this Magazine for the year 1909 (p. 385) Miss D. M. A. Bate gave a short account with some figures of a remarkably modified goat-like ruminant discovered in some remnants of cave-deposits in Majorca.[1] The chief peculiarities of this curious creature are that (1) instead of possessing the three pairs of incisors and pair of canines in the lower jaw, usual in the group, only the median pair of incisors remains, and these teeth are modified to form large permanently growing teeth like the incisors of a rodent; (2) the cannon bones on both the front and hind foot are extraordinarily shortened, this being especially marked in the former.

On a second expedition Miss Bate discovered that this remarkable form also occurred in Minorca, where it attained a somewhat larger size. In a recently published detailed description[2] of the skeleton the present writer has referred this large form to a distinct variety under the name *Myotragus balearicus*, var. *major*. Fortunately the collections made in Majorca were so large and complete that although in only a very few cases any bones of a single individual were found definitely associated, nevertheless it has been found possible to reconstruct the skeleton nearly completely, the only difficulty arising from the considerable individual variation in size occurring in the species. A figure of the mounted skeleton is shown on Plate XII.

In this reconstruction the skull and mandible are casts of the type-specimen, but the premaxillary region has been restored from another individual. The actual type skull and mandible are shown in the figure mounted on a separate stand. The vertebral column in part belongs to one individual, but has been completed with other vertebræ, and in some cases, especially in the caudal region, with plaster models. The ribs are mainly restorations. In the fore-limb only the scapula has been partly restored; all the rest is composed of actual bones, the collection including numerous examples of the

[1] An account of these caves was published by Miss Bate in this Magazine, 1914, p. 337.

[2] Phil. Trans., ser. B, 330, vol. ccvi, pp. 281–304 [pls. 19–22].

carpals and even of the tiny sesamoids. In the case of the hind-limb only the pelvis is restored.

The chief peculiarities of the skull are (1) the shortening of the face; (2) the position of the orbits, which look more upward and forward than usual; (3) the rigid attachment of the premaxillæ, the upper ends of which are firmly fixed between the maxillæ and nasals—in most related forms they do not reach the nasals, and consequently are weakly supported. As usual in the group the premaxillæ bear no teeth, at least in the adult. In one very young individual there is on one side a pit which may represent the alveolus of an evanescent tooth, though this is not certain. The mandible is relatively short and stout; the condyle, in spite of the peculiar modification of the incisors, is similar to that seen in Bovidæ, in which the normal arrangement of incisors and canines occurs.

As already mentioned the most remarkable character of this animal is the presence of a pair of large permanently growing incisors, the other incisors and canines being all suppressed, at least in the adult. These enlarged incisors have their anterior face covered with a thick coat of enamel, and in wear they together form a sharp cutting-edge, semicircular in outline. This edge must have worked against a hard pad on the premaxillæ, just as is the case with the incisors and canines of the normal Bovidæ.

The premolars are reduced to two in the upper, and in most cases only one in the lower jaw. The molars are remarkable for their extreme degree of hypsodonty, the roots of the first upper molar extending nearly up to the nasals, and its height being actually greater than that of m. 1 in a sheep of very much larger size. All the teeth seem to have been subjected to extremely hard wear.

The vertebral column presents no special peculiarities.

The fore-limb is chiefly remarkable for the shortness and stoutness of the humerus and metacarpus, while the radius and ulna are relatively slender bones. The shortening and antero-posterior compression of the metacarpus is far greater than that seen in any other member of the Bovidæ with the exception of the Takin (*Budorcas*), in which this bone is of strikingly similar form.

In the hind-limb the femur and metatarsus are much shortened, and here also great similarity with the corresponding bones of the Takin exists. One notable peculiarity is that in the adult the distal row of tarsals is fused to the metatarsus. In both fore and hind feet the vestiges of the lateral digits are much larger than usual, and the arrangement of the rather broad hoofs seems well adapted for climbing.

In the paper in the *Philosophical Transactions* above referred to, the various parts of the skeleton are compared with the corresponding bones in a number of other forms (e.g. the Rocky Mountain Goat (*Oreamnus*), the Goral (*Nemorhædus*), the Takin (*Budorcas*)), and from these comparisons it seems clear that *Myotragus* was a Rupicaprine antelope in which the feet, as in *Oreamnus* and *Budorcas*, were highly specialized for climbing on steep crags and screes, while the dentition has probably been modified for feeding on some very hard vegetable substance, as to the nature of which various suggestions

have been made. It may have consisted of lichens, the hard fibrous stems of heath-like plants, or, perhaps, tough bark and woody tissue. Why the food should have been thus restricted is not clear; the climate cannot have been very cold, for the remains of a large land tortoise (*Testudo gymnesica*, Bate) have been found in the same deposits. On the other hand, there may have been conditions of aridity which led to the stunting of the vegetation. In any case the food must have been widely different from that of other members of the group in which no trace of such a modification of the dentition has occurred.

The skeleton has been mounted with great skill and care by Mr. L. T. Parsons, jun. Some approximate dimensions of the specimens as mounted (see Plate XII) are:—

	cm.	inches.
Greatest length	88	34½
Height to tip of horns	63	24¾
Height to highest point of back . .	49	19¼
Height to top of scapula . . .	44½	17½
Height to top of pelvis	43	17

II.—The Principle of Saturation in Petrography: A Reply.

By Professor S. J. Shand, D.Sc., F.G.S., Victoria College, Stellenbosch, South Africa.

In exercising a debater's right to reply to criticism, I shall be extremely brief. My contentions, in two essays on the above subject,[1] were as follows:—

1. That the classification of rocks by silica percentage is unsatisfactory, and that a more natural basis for classification is available in the degree of saturation of the constituent minerals.

My critic, Mr. Scott, has not expressed any opinion on this point of comparison.

2. That the field evidence is overwhelmingly favourable to the separation of the rock minerals into two groups, those of one group being stable in the presence of free silica under magmatic conditions, those of the other group unstable; and that such experimental work as has been done supports that separation.

Mr. Scott has not brought forward a single fact in refutation of this, but only a set of assumptions, considerations, probabilities, possibilities, and plausibilities. (I wonder if he realizes how much of his two communications consists of statements such as "this *might* happen", "the reaction *may be* appreciably reversible", "metasilicates *might* dissociate", "if, *as is probable*, fayalite dissociates", "*probable* origin of garnets", "*probable* instability of pyrope", "*if* it had crystallized", and so on?)

The recent work of O. Anderson[2] on the system anorthite-forsterite-silica shows afresh the instability of the forsterite-silica association. It is claimed, however, that "corroded crystals of olivine may be imbedded in reaction products or other minerals in such a way that they are protected against further reaction with the magma. In this

[1] Geol. Mag., November, 1913, p. 508, and November, 1914, p. 485.
[2] *Amer. Journ. Sci.*, April, 1915.

case we may find for example olivine and silica together in the same rock". Such a rock would simply be classed as an aberrant variety of the stable type towards which it tends.

3. That the criterion of degree of saturation would make the existing mineralogical system more definite than it is, while by no means barring the way to future improvements.

Mr. Scott replies that "petrological affinities would be obscured". I am tempted to ask whether some alleged affinities could possibly be made more obscure than they already are? Jesting apart, it is my opinion that most of the supposed affinities between loosely defined rock types are partly subjective, and that in any case they are incapable of quantitative treatment and must remain so until the rock names themselves are more precisely defined.

Mr. Scott also argues that the occurrence of solid solution may make it impossible to determine the degree of saturation of a rock and asserts that "many minerals can take up free silica . . . in solution". A truer statement would be that "a few minerals have been plausibly assumed to hold traces of silica in solid solution". None of the known forms of silica is isomorphous with any other rock mineral, and in the absence of isomorphism or chemical relationship the amount of solid solution that can take place is very small. Day and Shepherd [1] show that artificial pseudo-wollastonite (which, by the way, is pseudo-hexagonal and so nearer in form to quartz than any rock mineral is) may hold an amount which is "certainly less than 2 per cent" of silica in solution. It remains to be shown that any silica at all would be occluded if the magma contained another molecule, such as nepheline, which combines with silica. It is safe to say that the influence of solid solution in concealing traces of quartz or of unsaturated minerals is too insignificant to effect even the smallest subdivisions of a quantitative mineralogical classification.

4. That rock names which transgress the boundary between the saturated and the undersaturated rocks are inadequately defined and should be avoided. I presume that my critic disagrees with me on this point.

The only positive proposals which I have made towards the framework of a classification are as follows (my first paper, p. 513):—

Class I. Oversaturated rocks.
,, II. Saturated rocks.
,, III. Undersaturated rocks.
(a) Monad metals undersaturated.
(b) Dyad and triad metals undersaturated.
(c) Both monads and dyads undersaturated.

The scheme seems to me to offer a definite gain in significance and precision of nomenclature at the cost of a very small rearrangement of ideas. Subdivision of the classes will proceed according to mineral ratios, and this may be effected either in a purely arithmetical way, as is done by Iddings, or with regard to eutectic proportions and the order of crystallization.

In concluding, I should like to thank my critic for his comments; adverse criticism is always helpful in "clearing the air".

[1] Journ. Amer. Chem. Soc., 1906.

III.—On a New Plesiosaur from the Oxford Clay.

By William R. Smellie, M.A., B.Sc., Hunterian Museum, Glasgow University.

THIS Plesiosaur was collected from the Oxford Clay at Peterborough by A. N. Leeds, Esq., F.G.S., and was acquired for the Hunterian Museum, Glasgow University, by Professor J. W. Gregory. The specimen has many striking resemblances to *Cryptocleidus oxoniensis*, but detailed examination showed that it could not belong to that species, and the differences existing in the paddle, shoulder-girdle, number of vertebræ, and conditions of ossification are such that it cannot be retained in that genus as now defined. The paddle closely resembles that of *Tricleidus*, but the shoulder-girdle alone is sufficient to prevent the inclusion of the specimen in that genus. It seems advisable to create a new genus, and as it may be some time before a full description can be published a preliminary account is here given.

Apractocleidus, gen. nov.[1]

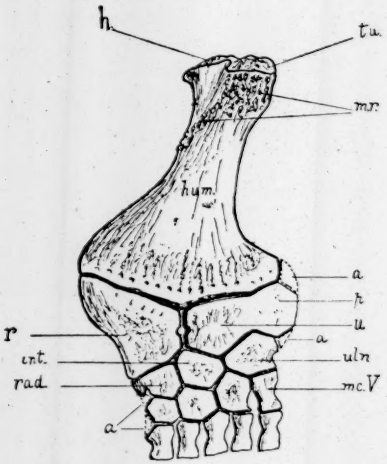
Plesiosaurs in which the neck is composed of about twenty-nine vertebræ of which the centra are wider than high and slightly higher than long. The oval articular ends are concave in the centre but convex near the margin. There are three pectoral vertebræ and twenty-three dorsals, or two pectorals and twenty-four dorsals. The shoulder-girdle is of Elasmosaurian type and so ossified as to form a very rigid structure. The coracoids are exceptionally broad and the postero-lateral processes are greatly produced. The dorsal rami of the scapulæ are widely extended in a similar fashion. The ventral ramus of the scapula is large, and in the adult the anterior portion has grown forward beyond the clavicles, which are very thin films of bone lying wholly within the visceral surface of the scapulæ. A rudimentary interclavicle may be present. In the mid-ventral line the scapulæ and the anterior parts of the coracoids impart a slightly carinate appearance to the shoulder-girdle. The humerus is greatly expanded distally and articulates with four elements. The pelvis is of great breadth, and the wide spread of the antero-external angles of the pubes taken in conjunction with the breadth of the shoulder-girdle indicates a genus of exceptionally broad build. The femur is slightly smaller and more slender than the humerus, and is not greatly expanded distally.

The genus is represented by one species, *Apractocleidus teretipes*, n.sp., the specific name (from *teres* = rubbed, well-chiselled, elegant, and *pes* = a foot) being descriptive of the symmetrical outline of the paddle.

In the type-specimen the parts preserved form a large portion of the skeleton of a fully adult individual, and the state of preservation of the bones is remarkably perfect even for Oxford Clay fossils. It differs from *Cryptocleidus oxoniensis* in the number rather than the

[1] The name *Apractocleidus*, meaning idle or functionless clavicle, has been adopted to accord with the names of the related genera *Tricleidus* and *Cryptocleidus*. For the suggestion of the name I am indebted to the Rev. Gavin Warnock, B.D.

form of the vertebræ, having twenty-nine cervicals, three pectorals, and twenty-three dorsals, while *Cryptocleidus* has thirty-two cervicals, three pectorals, and twenty-one dorsals. While the ossification is more complete than that found in larger and more massive specimens of *Cryptocleidus*, the posterior cervical ribs have remained free, a condition which may have evolved to mitigate the excessive rigidity which, as insisted on by Professor Williston,[1] must have existed in the thick part of the neck. The measurements given below and compared with *Cryptocleidus* will indicate some of the differences existing in the shoulder-girdle and pelvis. The humerus is like that



Proximal portion of left fore-paddle (outer side). (Type-specimen, V. 1091.) About $\frac{1}{10}$ nat. size. *a*, accessory ossicle (missing in original); *h*, head of humerus; *hum.* humerus; *int.* intermedium; *m.c. V.* fifth metacarpal; *m.r.* ridges for muscle insertion; *p*, pisiform (anchylosed to ulna); *r*, radius; *rad.* radiale; *tu.* tuberosity of humerus; *u*, ulna; *uln.* ulnare.

of *Cryptocleidus* in size and width of distal expansion, but the facets on the distal end are necessarily different to permit articulation with four elements in place of the two in *Cryptocleidus*. The epipodial bones are very similar to those of *Tricleidus* in shape as well as in number, and a well-marked foramen occurs between the radius and ulna. The hexagonal pisiform is anchylosed to the ulna, whereas it is free in *Tricleidus*. In some ways the specimen shows a curious blending of the characters of *Tricleidus* and *Cryptocleidus*, the paddle figured being a case in point, but in others it gives indications of being a more highly specialized type than either of those genera. The development of the shoulder-girdle has proceeded exactly on lines laid down by Dr. Andrews,[2] imparting increased rigidity to

[1] S. W. Williston, *Water Reptiles of the Past and Present*, 1914, pp. 80 and 91.

[2] C. W. Andrews, Ann. Mag. Nat. Hist. (6), vol. xv, p. 345, 1895.

the structure and rendering the clavicles functionless by increase in size of the ventral rami of the scapulæ. The coracoids are anchylosed to each other and to the fused scapulæ, while the glenoid is modified so as better to receive a directly forward thrust from the head of the humerus. Seeley[1] pointed out that perfect ossification and elongation of processes is coincident with higher organization and is more characteristic of Plesiosauria in the newer rocks.

In conclusion, I have to express my indebtedness to Dr. C. W. Andrews for providing me with every facility for studying the Leeds Collection at South Kensington, and my best thanks are due to Professor Gregory for the interest he has taken in the work and for the indispensable guidance I have received from him.

Some dimensions (in centimetres) of the type-specimen (V. 1091) are given below, together with some dimensions of specimens of *Cryptocleidus* for comparison.

	Atlas and Axis.	Fourth Cervical.
Length of centrum in mid-ventral line	4·4	2·8
Width of posterior end of centrum	2·9	3·6
Height of posterior end of centrum	2·4	2·9
Height to top of neural spine	5·5	7·4
	V. 1091.	R. 2616.[2]
Greatest length of combined scapula and coracoid	60·0	66·5
Width of united coracoids between outer ends of postero-external angles	62·5	57·1
		R. 2860.[3]
Greatest length of pubis	20·8	25·3
Greatest width of pubis	35·0	30·5
Width between antero-external angles of the two pubes	66·0	55·0
Humerus: Length	32·0	28·5
Width of distal expansion	24·6	21·4
Femur: Length	30·1	27·0
Width of distal expansion	19·5	16·0

IV.—Alpine, Lowland, and Jura Lakes in Switzerland.

By C. S. Du Riche Preller, M.A., Ph.D., M.I.E.E., F.G.S., F.R.S.E.

In the preceding paper[4] I dealt with the five principal and zonal sub-Alpine lake basins in relation to their age and origin, while the object of the present one is to group and consider the more prominent of the smaller Swiss lakes which I have had repeatedly occasion to visit and examine. Omitting the high altitude lakes, such as the Merjelen and the Engadine Lakes, which I described in previous papers,[5] as also the hundreds of lakelets disseminated throughout

[1] Seeley, Q.J.G.S., vol. xxx, pp. 449, 1874; Proc. Roy. Soc., vol. li, p. 149, 1892.

[2] Andrews, B. M. Cat., *Marine Reptiles of the Oxford Clay*, pt. i, pp. 195–6, 1901.

[3] Op. cit., pp. 190–1.

[4] Geol. Mag., 1915, pp. 215–24.

[5] Ibid., 1896, p. 97, and 1893, p. 222.

Switzerland, I shall confine myself to those lake basins from whose glacial or hydrographic features definite conclusions may be drawn. The illustrations (Sheets Nos. 1–4, Figs. I–X), having to cover the large area of Central and Northern Switzerland, are necessarily drawn to a small scale, but all particulars may be gleaned from the Swiss 1 : 25,000 contour map, to which the metric altitudes and dimensions in this paper correspond.

I. Lakes with Gorge Exit Channels.

1. *Lake Klöntal* (Sheet No. 1, Fig. I), one of the most picturesque though least known of the smaller Alpine lakes, lies in a Cretaceous basin between the Glarnisch and Wiggis massifs at altitude 826 metres, about 80 metres above Glarus in the Linth Valley. The present lake has shrunk from its original length of 6 km. to 2·5 km., its average width being 500 metres and its greatest depth 31 metres. Its two main affluents are the Klön and the Rosematter streams, the latter of which rises in one of the Glarnisch glaciers. Its exit is by a steep and narrow gorge channel through which the Löntsch, in a series of cascades about 2 km. in length, reaches the Linth Valley and discharges into the Linth at Nettstall, a short distance below Glarus, at altitude 440 metres, the average fall in the total length of 3 km. being thus 1 in 8. The lake has probably reached its present greatest depth by solution; the hanging valley in which it lies is of special interest in that its altitude indicates the former level of the Linth Valley floor, which, like that of the Zurich Valley in the same drainage area at the time of the Deckenschotter being deposited on Utliberg after the first glaciation, was subsequently eroded to its present level, about 400 metres lower.

2. *Lake Aegeri* (Sheet No. 1, Fig. I) occupies a basin in the Molasse area at the western base of Rossberg, at altitude 725 metres. Its present length of 5 km. is barely one-half of its former extent, while its average width is now 1 km. and its greatest depth 80 metres. As a storage basin it is of great industrial importance to Canton Zug. It derives special interest from the moraine wall which, beginning at its lower end, extends down to the Zug Valley. After overflowing this wall at a much higher level than now, the Lorze cut through it, as well as through the older glacial deposits below, down to the Molasse, thus forming the Lorze ravine, 6 km. in length at a fall of 1 in 20. Beyond this moraine and gravel bank fully 100 metres in depth, the Lorze built up an extensive cone in the direction of its flow towards the Reuss, of which it was then a direct affluent. The present Lake Aegeri, as a moraine-barred basin with a steep exit channel, was obviously formed during the recession of the Reuss Glacier, which, in its last advance, impinged upon Rigi and Rossberg, and then flowed round them in three branches.

3. *Ancient Sihl and Waeggi Lakes* (Sheet No. 1, Fig. I).—These two basins, although their lakes are extinct, may be grouped with the preceding ones as having moraine bars and steep exit channels, and as such may be termed "ancient glacier lakes in overflow valleys". As is seen from the sketch-plan, they lie in the Molasse area on the

left of Lake Zurich, at altitudes 840 and 800 metres, or about 400 metres above that lake, their length being 10 and 5 km. and their mean width 2 and 1 km. respectively. Both valleys were choked by the Linth Glacier advancing more or less at right angles through the Zurich Valley, and the lakes thus formed existed until during the recession of the glacier they overflowed the moraine walls,[1] and the Sihl eroded for itself an entirely new course through moraine and Molasse parallel to Lake Zurich, while the Waeggi-Aa found its old way again direct to that lake. The floors of both basins sloping considerably towards their exits, where erosion was, moreover, very active, the lakes gradually emptied themselves through their exit channels, which have an average fall of 1 in 40 and 1 in 30 respectively, as shown in the diagrams (Sheet No. 1, Fig. III[2]). The altitudes of the exits of both basins, which are practically hanging valleys about 400 metres above the present Lake Zurich, point to the same conclusion as that arrived at in relation to the altitude of the Klöntal Valley.

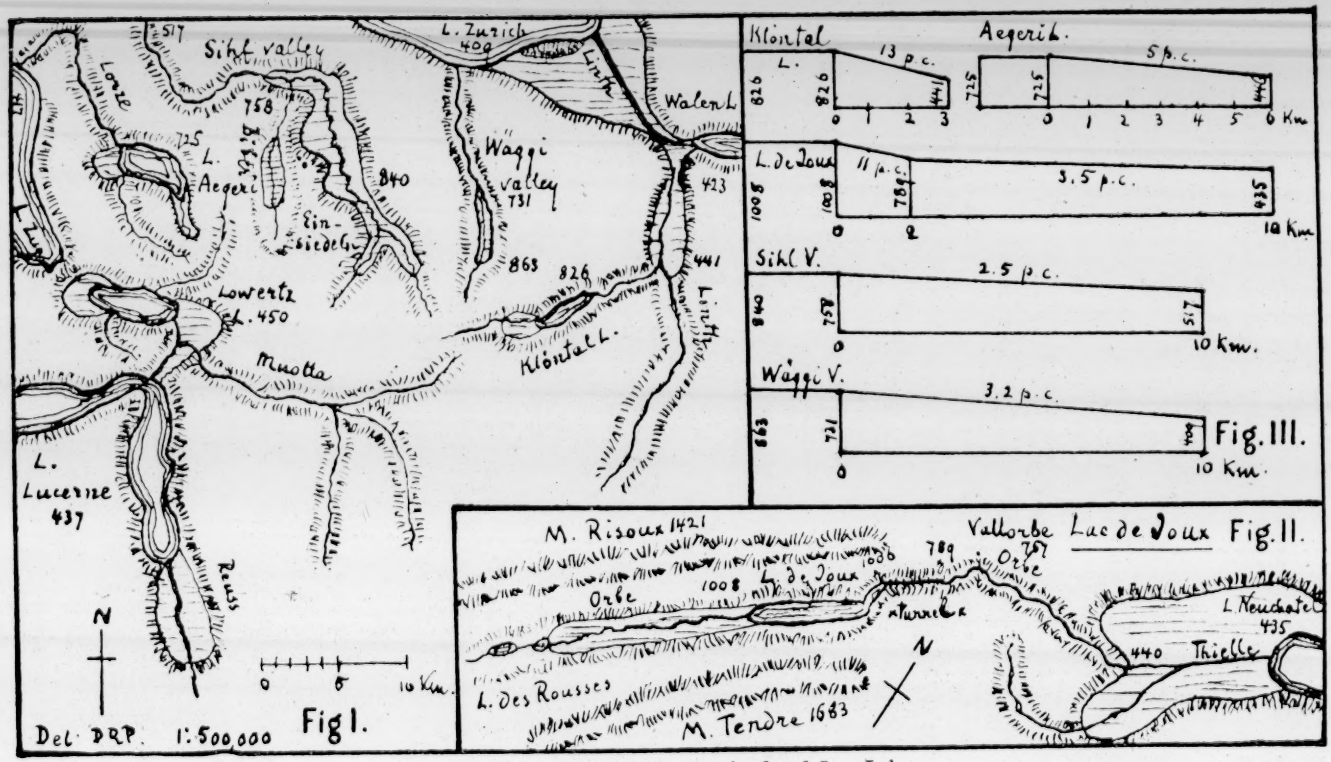
4. *Lac de Joux* (Sheet No. 1, Fig. II), well known for its winter sports, occupies, at 1,008 metres altitude, a Cretaceous basin between the two ridges of Mont Risoux and Mont Tendre, the former of which marks the crest-line of the Jura. As shown in the sketch-plan, the lake formerly extended fully 15 km. or double its present length of 7·5 km., higher up the valley, practically to the Lac des Rousser, from which issues its principal affluent the Orbe. The average width of the present lake is 1 km., and its greatest depth 34 metres. At its lower end it connects with a small outer lake, Lac Brenets, practically an outflow regulation and storage tank, at the end of which the Orbe plunges into a funnel or 'entonnoir', characteristic of the Jura, whence it issues 2 km. below at altitude 789 metres, viz. at a fall of 1 in 10, and then winds in a steep ravine past Vallorbe through the Jura until it discharges into the Yverdun Canal at the head of Lake Neuchatel. Lac de Joux owes its existence to one of the numerous shallow depressions in the Jura terraces parallel to the axis of the chain, and its gradual deepening to the action of solution in its Cretaceous bed, while its abnormal shrinkage is due to evaporation and percolation. Fortunately, the entonnoir, being at its exit instead of a fissure in its floor, saved the overflow valley from drying up. The lake and the River Orbe constitute important power factors in the industrial development of that part of the Jura, as do Lake Klöntal and Lake Aegeri in their respective areas.

II. Lakes with Moraine or Fluviatile Bars.

In this group I have comprised the smaller lakes which, with the one exception of Lake Sarnen, lie in the Molasse formation and at altitudes between 435 and 540 metres. For the sake of brevity their dimensions are given in the following table (p. 350):—

[1] An illustration of the moraine wall cut by the Sihl at Schindelleggi will be found in my paper, Q.J.G.S., vol. lii, p. 570, 1896.

[2] Both these ancient lakes are, in the near future, to be reconstituted for hydro-electric power purposes by valley bars, the Sihl basin alone being estimated to yield 60,000 horse-power.



FIGS. I–III.—Sheet No. 1. Lowland and Jura Lakes.

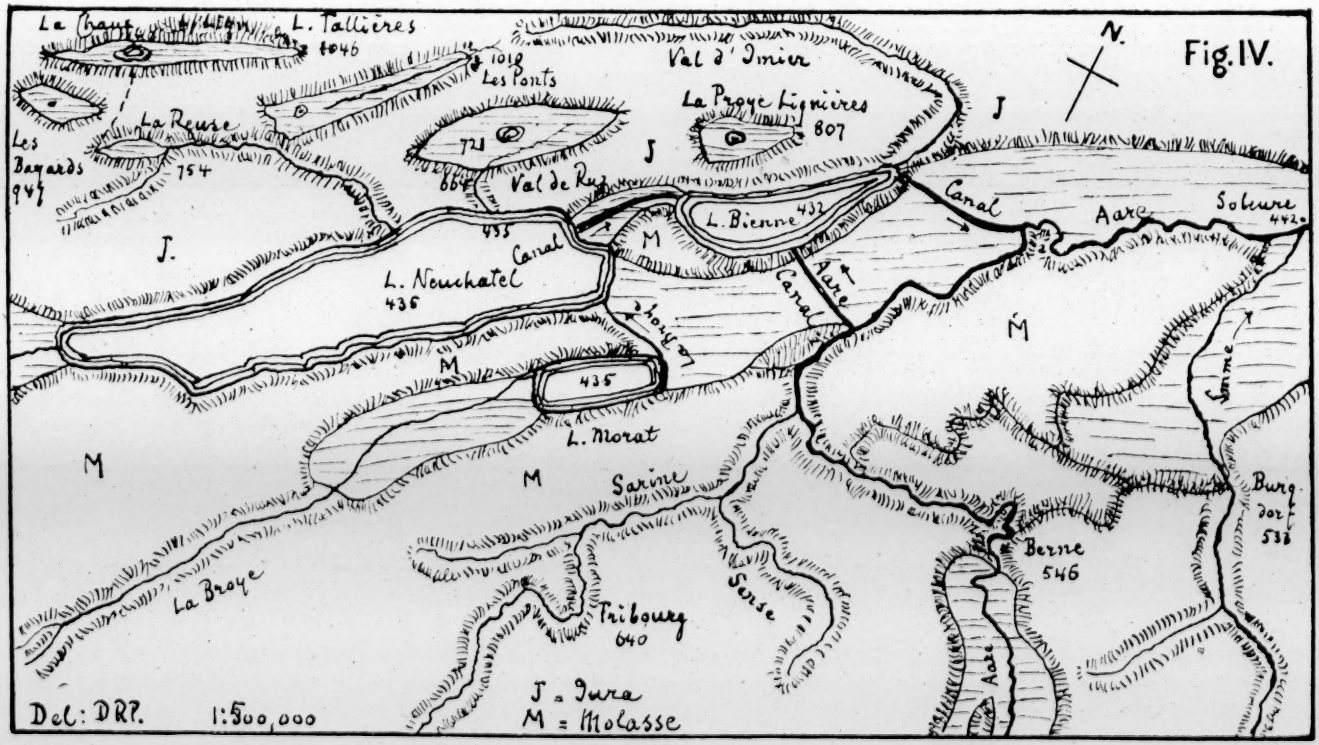


FIG. IV.—Sheet No. 2. The Neuchatel Jura (extinct Jura lakes).

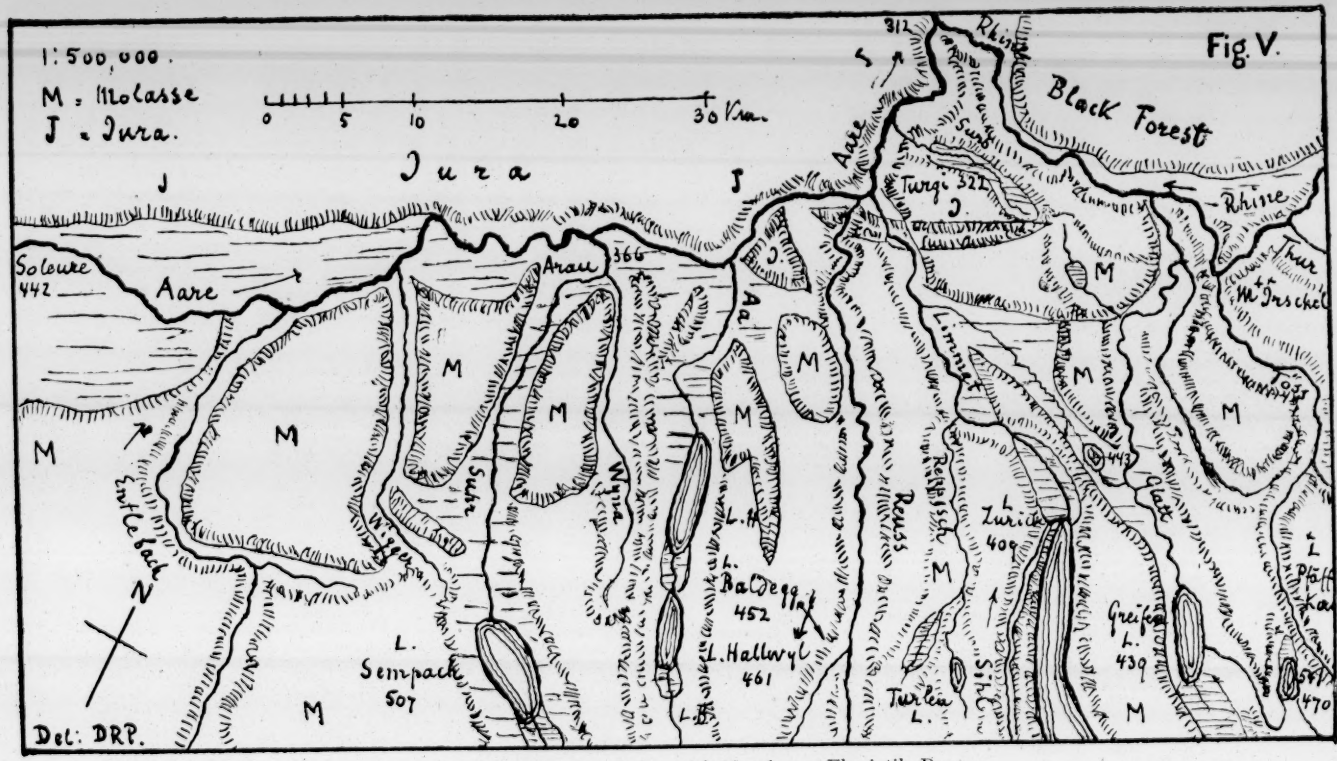
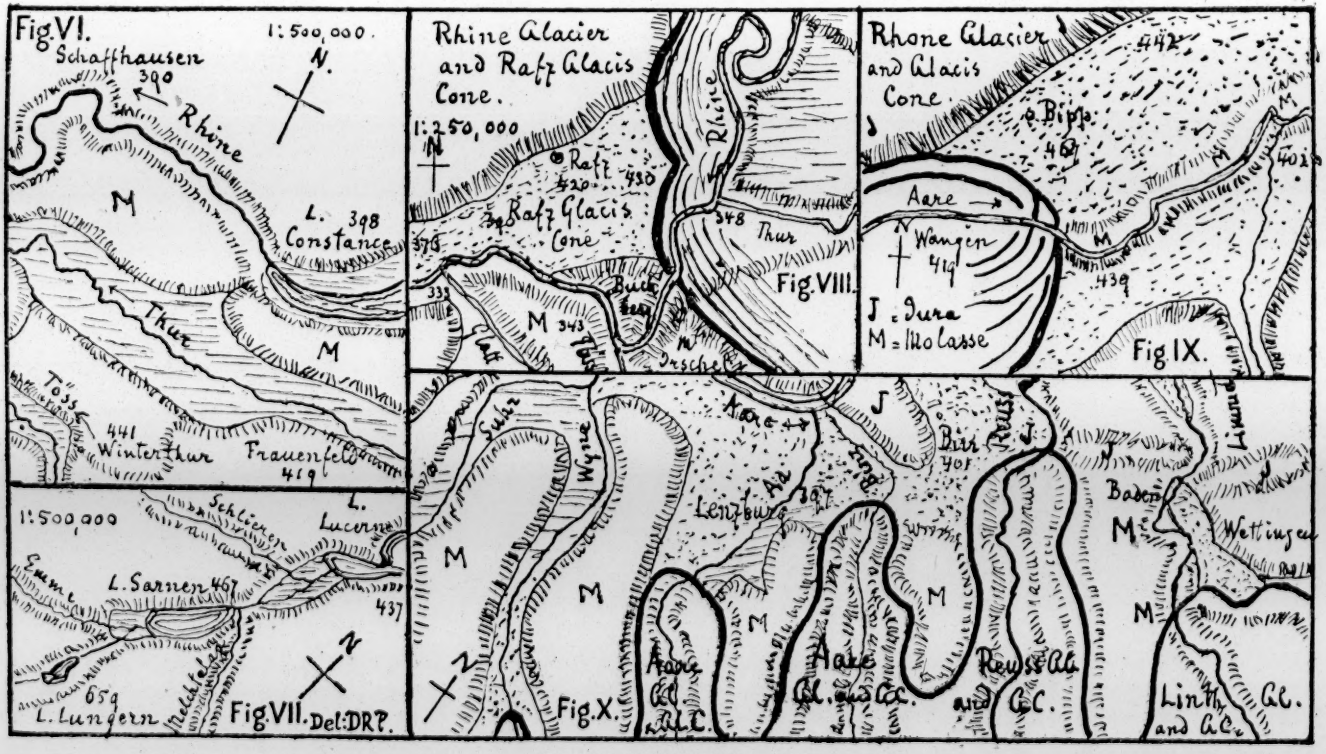


FIG. V.—Sheet No. 3. Lakes with Moraine or Fluviatile Bars.



FIGS. VI–X.—Sheet No. 4.

Lake.	Altitude.	Length.	Mean Width.	Greatest Depth.	In Drainage Area of
	metres.	km.	km.	metres.	
1. Pfäffikon . . .	541	2·5	1	35	Rhine
Greifensee . . .	439	6·5	1·5	33	,,
2. Baldegg . . .	466	5	1	66	Aare
Hallwil . . .	452	10	1	45	,,
Sempach . . .	507	8	2	83	,,
3. Lowertz . . .	450	3	0·8	11	Reuss
Sarnen . . .	467	5·5	1·2	10	,,
4. Morat . . .	435	10	3	51	Aare

1. *Lakes Pfäffikon and Greifensee* (Sheet No. 3, Fig. V) lie in shallow depressions of the Glatt Valley area and are twin lakes, being fed by the Aa as principal affluent, which, on emerging from Greifensee, takes the name of Glatt. Both have lost much of their former size, Greifensee having shrunk to less than half its former extent. They are both banked by moraine, and are the remnants of lakes formed during the recession of the Linth Glacier, which, probably augmented by a branch of the Rhine Glacier, filled the Glatt Valley and advanced to within a few miles of the Rhine at Eglisau. The Glatt Valley presents a noteworthy feature in that, after the Linth had been deflected back to the Zurich Basin after the last glaciation, it became a dried-up valley whose floor lies now from 30 to 50 metres higher than that of Lake Zurich. The same phenomenon characterizes the neighbouring valleys of the Rhine drainage area, such as the Thur and Töss Valleys, whose great width is altogether disproportionate to the size of the present affluents of the Rhine, and which must have been eroded by rivers of much larger volume.

2. *Lakes Baldegg, Hallwil, and Sempach* (Sheet No. 3, Fig. V).—The first two of these are twin lakes, being fed by the same river, the Aa, while Lake Sempach, in a neighbouring parallel valley, has for its principal affluent the Suhr, both rivers being tributaries of the Aare. The three lakes present precisely similar features, the first two occupying shallow basins in the Seetal Valley, while the third lies in a similar depression of the Suhr Valley. All three have shrunk to two-thirds of their former size, and the valleys, as also the contiguous parallel ones of the Wyna and Wigger, are disproportionally wide in relation to the small rivers. Like the valleys of the Rhine affluents, they must have been eroded by rivers of much larger volume and erosive force, or may have been occupied for a long period by shallow lacustrine expanses; possibly, here, as there, the indirect action of ice by pressure also contributed to give them the flat-dome lines of the Molasse formation. All three lakes lie in the area of the Aare Glacier and are banked by moraine; hence they must have been formed during the retreat of that glacier.

3. *Lakes Lowertz and Sarnen* (Sheet No. 1, Fig. I, and Sheet No. 4, Fig. VII) properly form part of the Lake Lucerne system into which they drain. Lake Lowertz, a remnant of the Reuss when the whole, or part of it, flowed along the northern base of Rigi, now discharges,

by its exit stream, into the Muotta, which formed the big alluvial cone of Ibach above Brunnen, and thereby banked Lake Lowertz; indeed, this cone was probably the primary cause of the Reuss being deflected to its present course. The lake, greatly reduced in size, is at a level 11 metres above that of Lake Lucerne. Lake Sarnen, which is close to the Brünig railway and 37 metres higher than the Alpnach basin of Lake Lucerne, into which it drains, was, like Lake Lowertz, banked by fluviatile alluvia, that is, by the cones of the Schlieren and Melchtal-Aa torrents. The small Lake Lungern, 192 metres above Lake Sarnen, now drains into the latter.

4. *Lake Morat* (Sheet No. 2, Fig. IV) is an offshoot of Lake Neuchatel and connected with the latter by the Broye, which is also its principal feeder. As is seen from the sketch-plan, it formerly extended, at its upper end, to double its present length, while at its lower end it formed part of the Lake Neuchatel and Lake Bienne system, which intercommunicated with the great lacustrine expanse formed by the River Aare. It was obviously the alluvia of this river, reinforced by the Sarine, which banked and separated Lake Morat and Lake Neuchatel, and also barred Lake Bienne. Connected with the Aare was also the great lacustrine expanse in the valley of the Emme between Burgdorf and Soleure (Fig. IV), which valley is even at the present day subject to partial submergence by periodical floods.[1]

III. Extinct Jura Lakes.

The Neuchatel Jura is remarkable for a number of interesting examples of extinct or quasi-extinct lakes and dried-up basins, of which the principal ones are shown in Sheet No. 2, Fig. IV. The one at the highest altitude—1,046 metres—is the La Chaux basin, 15 km. in length and about 2 km. in width, of which the small Lac Taillières—1,038 metres altitude—is the only lacustrine remnant. The latter, about 10 metres deep, has no visible outlet, but it is reputed to have an underground connexion with the River Reuss which issues at St. Sulpice, at altitude 754 or 284 metres lower, the vertical distance being 5 km., and the rate of fall, therefore, 1 in 2. It is, however, probable that the Reuss derives its copious volume from several underground sources.[2] Another extinct basin is that of Les Ponts, near Chaux de Fonds, altitude 1,010 metres, about 10 km. in length and 2 km. wide, which has a lakelet without exit. The same applies to the basin of La Praye, near Lignières, at altitude 807, 4 km. in length and 1 km. wide, with an exitless pool, and precisely similar is the large basin of Val de Ruz above Lake Neuchatel at altitude 721 metres, 8 km. long and 3 km. wide, except that this basin has an exit by a torrent, which, through the steep gorges of the Seyon, drains into the lake. The history of all these basins is the same. Formed

[1] Incidentally it may be mentioned that Lake Morat, like Lake Pfäffikon, is noted for its remains of lake-dwellings.

[2] An interesting case of subterranean torrents so characteristic of the Jura formation occurred a few years ago in the course of the works of the new tunnel from Frasne to Vallorbe (Simplon route), when a torrent rising in Mont d'Or and discharging normally by an underground passage near Pontarlier, suddenly burst through the tunnel near Vallorbe and discharged into the Orbe.

in shallow Jurassic depressions slowly deepened by solution, the water found an underground exit, the level of the lake was gradually lowered, and its floor, drying up, was covered with vegetable matter, leaving a pool in the deepest part, and reducing the basin to peat moss.[1]

IV. False Lake Floors.

By this unusual term I refer to certain extensive alluvia which have all the appearance of having been deposited as lake floors in standing water, viz. at a dead level, but which are extensive, flat glacis cones formed in front of the moraine walls of glaciers, while the latter, having reached the limit of their advance, remained stationary. As already shown in the preceding paper, these glacis cones, which have an average inclination of 1 in 200, were deposited by the streams flowing round and escaping under the moraine wall, until the glacier began to retreat, when the main stream overflowed the moraine wall and, more frequently than not, found its way outside the glacis cone and then eroded its own bed through the solid rock. Sheet No. 4, Figs. VIII–X, show the more important of these cones formed in front of the terminal moraines of the five principal glaciers at the extreme limits of the last glaciation. The two most extensive cones[2] are those of the Rhone Glacier in the Aare Valley below Soleure and Wangen, about 10 km. in length, and of the Rhine Glacier below Schaffhausen of about the same length, while the less extensive ones are those of the Aare, Ress, and Linth Glaciers. The Aare circumvented the Rhone Glacier cone by overflowing at the margin of the glacier and cutting its bed through the Molasse at a depth now 50 metres below the level of the cone (Sheet No. 4, Fig. IX), while the Rhine, by a similar process, eroded its new Molasse bed through the saddle between Mount Irschel and Buchberg (Sheet No. 4, Fig. VIII), where the present level of the river is nearly 80 metres lower than the glacis cone. Similarly, the Reuss broke through the Jura spur at Mellingen, leaving the glacis cone on its left, and the Limmat eroded the Molasse at Wettingen, leaving the glacis cone on its right. Thus the glacis cones were left high and dry, with all the outward appearance of lake valley floors.

Conclusion.

1. Whatever lakes or lacustrine expanses may have existed in the areas described during interglacial periods previous to the last glaciation, it is obvious that the present smaller lakes banked by moraine can, in their original larger extent, have been formed only during the retreat of the glaciers after the last general advance of the latter, that is, like the five principal lake basins considered in the preceding paper, towards the end of the Ice Age, while the smaller

[1] According to Dr. H. Walter (in a paper in 1896 on "Terrestrial Surface Changes in Canton, Zurich"), within the last 250 years since 1668, out of 149 lakelets shown in Gyger's authentic lake-map of Northern Switzerland of that time, no less than 73 dried up and were obliterated and 16 were largely reduced in size.

[2] The term delta does not apply to these cones, as they were not formed in standing water.

lakes banked by fluviatile bars are clearly post-Glacial. On the other hand, Lake Klöntal and Lac de Joux lie in old pre-Glacial valleys, of which that of the former was no doubt filled with or choked by the Glarnisch Glacier, upon whose retreat the lake was formed. Lakes Neuchatel and Bienne occupy the trough of the contact line of the Jura and the Molasse formations, and, lying in the zone of the Rhone Glacier,[1] were probably formed during the retreat of the latter; but both, as well as Lake Morat, were subsequently banked by the post-Glacial alluvia of the Aare.

2. The remarkable shrinkage of all the smaller lakes, compared with the much larger areas covered by them at the time of their formation, cannot be due to want of precipitation, for neither north nor south of the Alps is there any marked diminution of the annual rainfall. The cause must therefore be sought in gradually increasing loss of water by evaporation and percolation. Increased solar heat during dry summers causes increased melting of the glaciers and superabundance of water in the lakes and lowlands, which is, however, generally followed by a shortage of supply in winter, so that the increased evaporation of the lakes in summer is not compensated by additional volume of water in winter.[2] Still greater is the loss by percolation through the dry soil of the drainage areas and the permeable rock strata below, by which, as shown by the dried-up basins of the Jura and certain quasi-dried up valleys in the lowlands, large masses of water are abstracted from the surface and circulate underground. The gradual shrinkage not only of the smaller lakes but of the five principal zonal lake basins as the great hydraulic storage and regulation reservoirs of Switzerland would be a disquieting phenomenon were it not that the areas dried up are so much land reclaimed, and that the shrinkage itself may be but a cycle in the evolution and lapse of time.

V.—On the Formation of the River Tyne Drainage Area.

By Edward Merrick, M.Sc.

(*Concluded from the July Number, p. 304.*)

D. The Earth-Movements considered Stratigraphically.

An important factor in the formation of this drainage area as above outlined is the movement of the rocks after they had been reduced to a surface comparable with a peneplain. These movements are now reviewed to see if any assumptions have been made which are probably incorrect from stratigraphical evidence.

1. The Stublick Dyke was supposed to be later than the formation of the junction plane, else it could not affect the contours as indicated on the north of itself and the Tyne.

[1] The boulders of Rhone Valley (Valaiz) origin on Mt. Chaumont above Neuchatel, at an altitude of 1,220 metres or 785 metres above the lake, were deposited by the Rhine Glacier of the maximum glaciation.

[2] Of this frequent shortage in winter, practical proof is afforded by the fact that most, if not all the large Swiss hydro-electric power installations have added reserve steam-power to their hydro-turbines to meet that shortage.

2. The Cross Fell Anticline was supposed to be later, or partly later, than the formation of the junction plane, else it could not have affected the contours as indicated on the north, east, and south.

3. The Pennine Fault was supposed to be later than the formation of the junction plane, else it could not have affected the contours as indicated on the east and west.

4. The *throw* of the Pennine Fault since the formation of this plane was supposed to be measured by the throw of the contour-lines upon its surface.

5. Any earlier faulting will alter the amount of throw of the geological deposits.

6. The conjecture was also made that the movements in this area might follow pre-existing lines of weakness and motion.

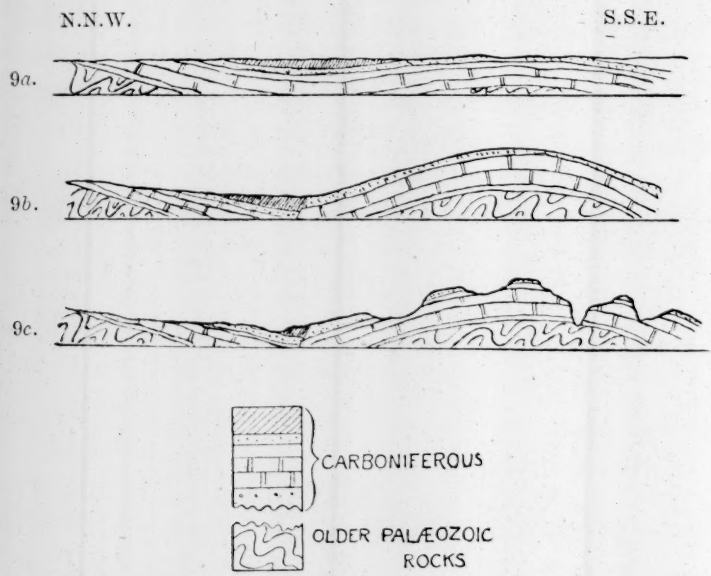


FIG. 9. Simplified north to south section along the Cross Fell escarpment.
,, 9*a*. Condition late in the Carboniferous period.
,, 9*b*. The peneplain buckled, altering land-levels and levels of rock outcrop.
,, 9*c*. Erosion since the buckling.

These hypotheses, if correct, necessitate the existence of—

1. Pre-Mesozoic tilting or folding and planing, producing a plain of marine denudation, peneplain, or surface of planation. This rock surface, when covered by later deposits, would become a junction plane or even a plane of unconformity.

2. Mesozoic or later folding and faulting producing an undulating junction plane.

3. Contemporary erosion which on continuation during later periods has produced the present-day hills and valleys (Fig. 9).

Stratigraphical Evidence.

1. In this area post-Carboniferous and post-Permian movements are known to have given changing directions of strike and dip to the rocks. Some of these movements are known to be pre-Permian, but owing to the absence of Mesozoic rocks it is not known if the post-Permian movements are also post-Mesozoic ones. Pre-Permian planing is proved by the unconformity between the Carboniferous and Permian formations, both in this and neighbouring areas. It is proved in South Durham by borings at Bradbury Carrs and Elstob, while at Conscliff the Magnesian Limestone is seen to rest upon Millstone Grit. The Yellow Sands are so irregular that the occurrence of the Magnesian Limestone upon the Millstone Grit cannot be held as proving either overlap or erosion of the Yellow Sands. Permian erosion is proved in the Eden Valley by the presence in the Brockrams of Carboniferous Limestone pebbles which are regarded as coming from the Cross Fell escarpment, thereby implying the pre-existence of the Pennine Fault. The latest erosion of the Tyne area can only be returned as post-Permian from the stratigraphical evidence of the solid rocks.

2. Evidence of these movements is found in the neighbouring areas of the Rivers Eden and Tees, where the land sank below sea-level, then rose again with some covering of Liassic deposits that now exhibit signs of disturbance. The Pennine Fault, by disturbing the Triassic sandstones, is an example of Mesozoic or later faulting which follows an older line of weakness.

In describing the main valley and the collecting areas on its flanks, the difference in surface levels was attributed to the Stublick Dyke and the Cross Fell Anticline producing undulations of a rock surface composed of strata with a common trend. If such were actually the case, then the highest elevations reached by the different strata on its flanks should vary in the same manner as the difference in surface levels of the rock surface. Such, indeed, is found to be the case. In a paper entitled "A New Flora of Northumberland and Durham", by Messrs. J. G. Baker and G. R. Tate, 1868, there is a geological introduction by Mr. G. Tate. In this paper it is mentioned that the rocks attain different elevations on the two banks of the Tyne, but no explanation is given for this. There is also a botanical map founded upon the river drainage, but nothing is said about the origin of the watersheds. The highest recorded outcrop of the Permian formation in Northumberland is that of the yellow sands (now obscured) at Closing or Clousden Hill, Killingworth, near the 200 foot contour-line.

Dr. D. Woolacott states that the highest point on the Permian escarpment in Durham is at Warden Law, which is 646 feet high. From this height about 120 feet of sand and gravel must be deducted, leaving 526 feet for the height of the rock surface. Other exposures are near the 500 foot contour.

It is noticeable that the older rocks in the west are more elevated than the younger ones in the east, yet it does not necessarily follow that they form an older part of the Tyne drainage area.

TABLE IV.

ROCK ELEVATIONS IN FEET.

Strata.	Northumberland.	Durham and Cumberland.	Difference in Level.
Magnesian Limestone .	Marden (100)	Warden Law (526)	426
Yellow Sands . .	Killingworth (200)		
Coal-measures . .	Heddon Laws (500)	Pontop Pike (1,034)	534
Millstone Grit . .	Heddon Laws (500)	Cross Fell (2,930)	2,430

Though the outcrop of the Millstone Grit has been arched up some 2,500 feet higher at Cross Fell than in the Tyne Valley, yet the change in level of the land surface and dip of the strata is so gradual that it is similar to the passage of horizontal strata into a monoclinal fold which gradually breaks into a fault along the Tyne Valley. On the other hand, when examining the Geological Survey maps of the older rocks forming the inlier below Cross Fell, it is observed that they are bounded on the north by normal faults throwing north, and on the south by normal faults throwing south.

The Carboniferous rocks on the top of this inlier are very slightly disturbed, being almost horizontal, while those in the synclines flanking it (as near Haltwhistle and Fourstones) are rolling and associated with short and sharp anticlinal and synclinal folds. These disturbed rocks lie at a lower elevation than the surface of the inlier, giving it the appearance of a buttress against which they have been pressed; but as they occur some miles north of the inlier, this appearance may be deceptive. The above description would almost fit the Craven area if Ingleborough were put for Cross Fell, and the other place-names also changed.

The drainage system of the Tyne has been described above as due to the denudation of a composite plane of rock. Because the close connexion between the field structure and drainage supports this view, this river system is therefore not regarded as one superimposed upon it by the denudation of a younger deposit now completely removed. Yet if this area were ever covered by a deposit of fairly uniform thickness, laid upon this rock surface as an unconformity, the resulting drainage would still be much the same as it is now, provided that this young deposit were older than the earth movements already described.

The denudation of the area is so closely related to the outcrops of its rocks (nearly all of which belong to the younger Palæozoic period) that it has the appearance of continuous action during the later periods, especially so as the most elevated area is most eroded. That this may not be the case is seen on comparing it with a younger area with greater denudation.

A suitable area for such comparison is the Weald, where post-Cretaceous movements arched the Chalk into an anticline now denuded. When a line of correlation was drawn as an anticline connecting the two escarpments, its height above the present surface was termed the "Geological Elevation" of the Chalk by Mr. W. Hopkins. This is a height of some 2,500 feet, and by a happy chance the same height that the Millstone Grit on Cross Fell has been arched above its outcrop in the Tyne Valley. In the Weald the

line of geological elevation may not represent the actual position of the rocks in time past, but in Tynedale the geological elevation and former position of the Millstone Grit are identical, for the fell tops are capped by it, proving that it once crossed the valleys between them. Denudation in the Weald has cut to a greater depth than in the Tyne area, and as it occurred there in post-Cretaceous times the denudation here may not have acted continuously since the Permian period; in fact, it may be quite young. On the other hand, Tynedale may be regarded as containing better weather-resisting rocks than the Weald. Some time will have to elapse before Cross Fell is replaced by a river and the Tyne Valley becomes a synclinal mountain (Fig. 9*c*).

A noticeable feature of the Tyne between St. Peter's and Hebburn is that it flows between two rocky banks for a little distance; elsewhere, though rock be exposed in its bed or on one bank, the other bank is generally composed of superficial deposits. A little further east the Tyne passes the outlier of the Permian escarpment on Tynemouth cliffs and then joins the sea.

The Ouseburn in Jesmond Dene and the Burn at Newburn have this rocky feature also, but not the Team nor the Derwent. The rocky and narrow valleys are cut nearly at right angles to the strike of the strata, while the other and wider valleys are nearly parallel with the strike. These rocky streams are also at a less depth below the restored surface of the land than the other streams. This nearness to the original surface brings about the following effects (which are independent of the recent changes in sea-level):—

1. An example of stream action found in the collecting areas of its tributaries.
2. An appearance of youth through less depth of erosion.
3. An appearance of age, because the Tyne is tidal here and at its base-level of erosion (for the present moment).

This part of the river bears comparison with the rivers from the Weald cutting through the Chalk escarpment and then running either into an area of Tertiary rocks or the sea.

Coincidence with old lines of weakness, etc.

The following examples show the relationship between the present land surface and older features:—

1. The Pennine Fault through being pre-Permian and post-Triassic is an old line of weakness and motion. It has produced part of the western watershed to the Tyne.
2. The present-day watershed from Cross Fell to Cleadon lies above the pre-Carboniferous ridge which was inferred by Mr. J. G. Goodchild and given in position in Mr. Jukes-Browne's *Physical Geology*.
3. The Carboniferous strata below the Millstone Grit in the Tyne Valley are collectively thicker than those on the southern watershed.
4. That this watershed follows the general direction of the junction plane between the Coal-measures and the Permian strata is shown in a section drawn by Messrs. Wood, Taylor, and Marley from Hownes Gill to Monkwearmouth. There is also a slight increase of slope of the junction plane near the coast.

TABLE V.

Slope of the South Watershed.	*Slope of the Unconformity.*
Cross Fell to Muggleswick, 77 feet per mile.	
Muggleswick to Cleadon, 36 feet per mile.	Painshaw Hill to Monkwearmouth, 133 feet per mile.
Cleadon coast out to sea on the sea-bottom, 20 feet per mile.	

5. Having made allusion to the parallelism of the younger deposits with the junction plane below them, I may next point out the effects of the forces producing the present-day land surface upon the position of the deposits now being formed.

That the contour-lines of the sea-floor have been produced by these forces is illustrated in the following table, in which it is observed that the contours near the coast are close together, while the deeper ones are wider apart, and it is most prominent that the deeper soundings are between two and three miles nearer inshore off the mouth of the Tyne than elsewhere. This points to the continuation of the Tyne trough seawards, and the spacing of the contour-lines is similar to that along the southern watershed.

The average slope of the sea-floor off the mouth of the Tyne—23 feet per mile—is greater than the probable slope of the rock surface of the main valley before denudation—17 to 18 feet per mile.

TABLE VI.

Locality.	25 feet.	50 feet.	75 feet.	100 feet.	150 feet.	200 feet.
	m.	m.	m.	m.	m.	m.
The Rockers, Blyth . .	0·61	1·35	1·72	2·48	5·4	10·8
St. Mary's Island . .	0·3	0·6	1·18	1·6	4·43	10·1
Sharpness Point (River Tyne Outlet) . . .	0·26	0·7	1·2	1·8	4·5	8·65
Lizard Point . . .	0·2	0·4	0·82	1·62	3·65	8·65
Holey Rock (Roca) . .	0·45	1·0	1·9	2·88	4·35	9·5
Salterfen Rocks . .	0·25	1·5	2·5	3·25	4·85	+10
Feather Bed Rocks . .	0·4	1·0	2·5	3·4	6·5	+ 8·5

The distances in miles are taken from the high-water mark at the base of the cliffs at the rocky points of the mainland. The figures are obtained from the 1 in. Ordnance Maps. All these rocky points do not lie in one line as a base, but the first four are nearly in line, and also the last three in another line.

6. The contours off the mouth of the Tees are seen to be produced by the forces which made the Cleveland Hills (Fig. 10).

E. Relationship to other Drainage Areas.

The superficial deposits in this area prove that the land stood recently at a higher elevation, and that the present tidal part was excavated to a considerable depth which was above the sea-level of that period. This elevation would naturally be accompanied by an

increase of coastal land; the greater the amount of land and elevation the greater the probability that the streams now running into the sea would run into the continuation of the Tyne over the extra country. This would cause the present watersheds to be deflected so as to include these drainage areas, but these deflections could only affect the south and north watersheds. The west one would remain unaltered from this cause.

It may be mentioned here that several authorities believe that the western watershed has been altered by tributaries from the Eden capturing the Irthing. The western watershed, through being part of a long one, has a feature shared by many other rivers. This long watershed separates the streams flowing into the North Sea from those to the Atlantic, Irish Sea, and English Channel. The continuation of this watershed in Europe separates the rivers flowing to the North Sea from those to the Mediterranean Sea, and ultimately joins the watershed between the Atlantic and Pacific Oceans. A geological feature of this watershed is that from the North to the South of England it lies upon rocks becoming younger and younger, as also do the strata on the coast, the result being that the more south a drainage area is, the younger it appears from the deposits contained in it.

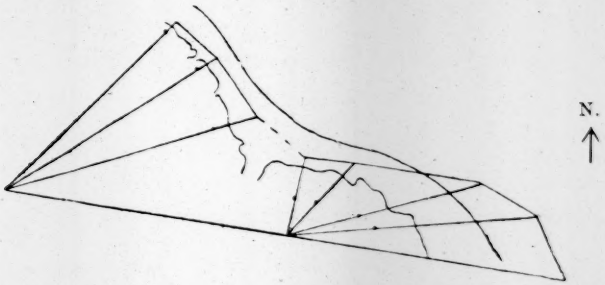


FIG. 10.—Soundings (diagrammatic) off the Mouth of the Tees following the sea-level (0 feet) contour of the peneplains from Cross Fell (Palæozoic rocks) and the Cleveland Hills (Mesozoic rocks).

The continental continuation of this watershed enters the Alpine region, which was a centre of great mechanical energy. Is it an allowable inference that movements contemporary with the formation of the Alps would follow older lines of weakness to an increasing degree as the distance from this centre of activity increased, and ultimately with complete coincidence, where young deposits are absent, that the age of these movements would consequently be dated further back?

At the present time the Tyne area can be considered as part of a larger unit which includes all rivers receiving tributaries from Cross Fell or which act as tributaries to them. This unit resolves itself into the Eden and its tributaries on the west, and the Tees, Wear, and Tyne on the east. To these the Blyth, Wansbeck, and Coquet might be added.

The southern watershed to this system runs from the Lake District to the Cleveland Hills, and is generally associated with anticlines.

A somewhat similar watershed is the northern one from Loch Ryan to the coast north of the Coquet.

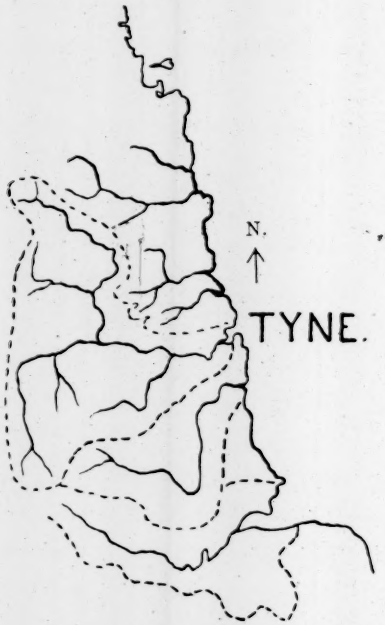


FIG. 11.—Map of the eastern half of the Cross Fell drainage area. Dimensions of Tyne area as given by Mr. T. J. Taylor in 1851 :

	Sq. miles.
North Tyne and Reidwater	473
South Tyne to confluence with North Tyne .	267
Tyne below confluence	402
Total . . .	1142

The rivers associated with these watersheds show some similarity in their courses :—

	NORTH WATERSHED.	SOUTH WATERSHED.
N. Slope.	River Tweed.	River Tees.
	River Clyde.	River Eden.
	Firth of Forth.	Tyne Valley.
	(Nothing.)	River Eamont, Ullswater.
	River Doon and Loch Doon.	River Derwent and L. Bassenthwaite.
	Forth and Clyde Canal.	Proposed N/C. and Carlisle Canal.
S. Slope.	River Dee and Loch Ken.	River Leven and Lake Windermere.
	Solway Firth.	Morcambe Bay.
	River Tyne Catchment.	Humber Catchment.

VI.—The Bekinkinite of Barshaw (Renfrewshire), and the Associated Rocks.

By G. W. Tyrrell, A.R.C.Sc., F.G.S., Lecturer in Mineralogy and Petrology, University of Glasgow.

(*Concluded from the July Number, p. 311.*)

Chemical and Mineralogical Composition.

THE chemical composition of the Barshaw bekinkinite has been determined by Mr. E. G. Radley, of the Geological Survey (Table I). In the Glasgow Memoir (pp. 134–5) Mr. Bailey points out the general similarity of this analysis to those of picrite, nepheline-basalt, and Hillhouse basalt, from the Lower Carboniferous of the Midland Valley of Scotland, and also to the type bekinkinites of Madagascar. The Barshaw rock, however, is distinctly richer in lime and alumina than the other Scottish rocks, indicating a greater richness in the anorthite molecule. This is well brought out in the calculation of the mineral composition from the chemical analysis (see later). The ultrabasic end-differentiates of the Scottish analcite rocks tend either to be enriched in the bisilicate minerals or in olivine. The former type includes the Barshaw bekinkinite, the picrites, and some Ayrshire theralites; the latter includes peridotites, kylites, and certain nepheline- and analcite-basalts. Chemically the bisilicate type tends to be rich in lime and ferrous iron, and comparatively poor in magnesia, with, for the silica percentage, a rather large amount of alkalies. The olivinic types are rich in magnesia, with low silica and alkalies. In the American Quantitative Classification the Barshaw bekinkinite falls into the subrang III, 6 . 4 . 5 (named 'papenoose' by Lacroix), whereas the bekinkinites of Madagascar fall into the neighbouring subrangs III, 6 . 3 . 4 (limburgose) and III, 6 . 3 . 5 (unnamed). The majority of the Scottish analcite rocks fall into limburgose (III, 6 . 3 . 4), monchiquose (III, 6 . 2 . 4), or camptonose (III, 5 . 3 . 4), subrangs whose clear relationships are shown by their numerical symbols.

The chemical composition of lugarite is illustrated in Table I by analyses of the Barshaw and Lugar rocks, both of which are here published for the first time. It is not intended to discuss these analyses fully in this place, as a full discussion will appear in a detailed paper on the Lugar sill. It will be seen that the analyses are unique in British petrography, and as far as is yet known in the world. In the American Quantitative Classification, the type-rock from Lugar falls into II, 7 . 1 . 5, a hitherto unoccupied and unnamed subrang next to lujavrose (II, 7 . 1 . 4). The latter contains the lujavrites (eudialyte-nepheline-syenites) of the Kola Peninsula, Finland, and related rocks from Greenland, Portugal, and the Transvaal,[1] all of which are much richer in potash than lugarite. The Barshaw lugarite falls into II, 6 . 1 . 5, but in a position transitional to II, 7 . 1 . 5.

The quantitative mineral composition of the rocks has been obtained in two ways, by means of the Rosiwal micrometric method, and by

[1] J. P. Iddings, *Igneous Rocks*, vol. ii, p. 279, 1913.

calculation from the chemical analyses. In making the Rosiwal measurements it was not found possible to treat the leucocratic minerals separately, as their boundaries were so indefinite and obscured by alteration. Hence they were measured as a group of colourless minerals (groundmass) as against the easily measured coloured minerals. To arrive at the mass proportions of the constituents from the data thus obtained, it was necessary to know the specific gravity of the groundmass. This was obtained by calculation, knowing the specific gravity of the rock as a whole, and the specific gravities and volume proportions of the coloured minerals. These measurements do not give the complete mineral composition, but they provide information as to the relative quantities of the coloured minerals, and the ratio between the light (felsic) and dark (mafic) constituents.

TABLE I.

	I.	II.	III.
SiO_2	40·87	46·29	46·58
TiO_2	2·85	2·37	·53
Al_2O_3	16·23	17·47	15·25
Fe_2O_3	1·31	2·24	7·58
FeO	7·37	7·07	4·70
MgO	9·83	2·10	2·30
CaO	11·13	5·82	4·68
Na_2O	2·78	8·69	8·93
K_2O	·53	1·47	1·70
H_2O (above 105 C.)	4·28	5·12	4·53
H_2O (at 105 C.)	1·35	·69	1·91
P_2O_5	·52	·70	1·04
MnO	·64	·28	·10
(Co Ni) O	·06	—	—
Li_2O	? tr.	—	—
CO_2	·38	none	none
FeS_2	·21	—	—
BaO	—	·09	—
	100·34	100·40	99·83

I. Bekinkinite,[1] III, (5) 6 . 4 . (4) 5 (Papenoose). Barshaw, near Paisley. Analyst, E. G. Radley. Quoted from *Geology of the Glasgow District* (Mem. Geol. Surv.), 1911, p. 134.

II. Lugarite, II, (6) 7 . 1 . (4) 5. Lugar, Ayrshire. Analyst, A. Scott, M.A., B.Sc. Analysis published for the first time.

III. Lugarite, II, 6 (7) . 1 . (4) 5. Barshaw, near Paisley. Analyst, A. Scott. Analysis published for the first time.

In order to calculate the quantitative mineral composition from the chemical analysis of a rock it is necessary to know the exact chemical composition of the constituent minerals. These data,

[1] The figures following the name of the rock show the exact position of the rock in the American Quantitative Classification. See Cross, Iddings, Pirsson, and Washington, *Journ. Geol.*, xx, pp. 550–61, 1912.

especially in regard to the complex pyroxenes, amphiboles, and micas, are rarely available. It is generally necessary to make certain assumptions as to the chemical composition or amount of one or more minerals present in the rock, and to test the correctness of these assumptions by the congruity of the result with what is known or reasonably conjectured as to the quantitative mineral composition of the rock. In the present case, for example, the exact chemical composition of the olivine, titanaugite, and barkevikite present in the rocks is not known. There is available, however, an analysis of barkevikite [1] from the lugarite of Lugar, by Mr. A. Scott, and it is a reasonable assumption, considering the similarity of the rocks, that the barkevikite of the Barshaw rock has a composition similar to that of the Lugar mineral. There is also an analysis of titanaugite [2]

TABLE II.

MODES OBTAINED BY ROSIWAL MICROMETRIC ANALYSIS.

	I.	II.	III.	IV.	V.	VI.
Titanaugite	23·2	14·5	12·4	—	21·7	29·8
Ægirine	—	—	—	3·8	—	—
Barkevikite	13·5	24·4	26·0	12·5	17·2	14·7
Olivine (serpentinized)	1·3	—	—	—	—	18·6
Iron-ores	5·8	7·0	4·2	·6	5·0	4·9
Pyrite	—	—	—	—	—	·2
Apatite	2·3	2·2	2·4	2·5	3·1	1·1
Plagioclase	53·9	51·9	9·8	80·6	53·0	30·7
Orthoclase			16·8			
Nepheline			17·3			
Analcite			11·1			

Summation 100 in each case.

I. Lugarite, variety 1. Barshaw.
II. Lugarite, variety 2. Barshaw.
III. Lugarite, variety 2. Barshaw. Duplicate measurement.
IV. Lugarite, variety 3. Barshaw.
V. Lugarite, type-rock from Lugar sill.
VI. Bekinkinite. Barshaw.

from the porphyritic essexite of Crawfordjohn, Lanarkshire, also made by Mr. Scott. The optical properties of this mineral are very similar to those of the titanaugite of the Barshaw rocks, and the chemical composition of the Crawfordjohn essexite cannot be so very different from that of the Barshaw bekinkinite. Hence it is legitimate, at least in a first trial, to use the Crawfordjohn analysis in calculating the composition of the Barshaw rock. Actually this analysis gave a good result for the Barshaw lugarite, but not for the bekinkinite.

[1] A. Scott, "Barkevikite from Lugar": Min. Mag., xvii, p. 140, 1914.

[2] SiO_2, 42·65; TiO_2, 4·17; Al_2O_3, 7·47; Fe_2O_3, 4·15; FeO, 9·98; MgO, 11·70; CaO, 13·75; Na_2O, 4·90; K_2O, tr.; P_2O_5, 1·38; H_2O + ·04; MnO, tr.; total, 100·19. The Al_2O_3 contains some thoria, probably present as inclusions of a thoria-bearing mineral. The P_2O_5 probably represents inclusions of apatite.

It was also found necessary to fix the amount of olivine in the bekinkinite. It was assumed that olivine was present in the same amount (18·5 per cent) as it occurred in the norm, calculated according to the methods of the American Quantitative Classification. This assumption was much strengthened by the fact that the amount of olivine (serpentinized) in the rock, measured by the Rosiwal method, came to 18·6 per cent. In the calculation of lugarite it was found necessary to fix the amount of analcite present. This was taken as 12 per cent, since rough measurements (micrometric) of the amount of analcite present in two varieties of the Barshaw lugarite gave 11·1 and 13·8 per cent respectively.

The various compositions, as given by the two methods, are set out in Tables II and III.

The duplicate measurement of variety 2 of lugarite (Table II, col. III) was made a year earlier than that of col. II, and on fewer slides. Notwithstanding, the agreement between the two is sufficiently good.

TABLE III.

MODES OBTAINED BY CALCULATION FROM THE CHEMICAL ANALYSES.

	I.	II.	III.
Titanaugite . .	11·9	16·5	9·1
Ægirine . . .	—	—	6·0
Barkevikite . .	16·5	10·2	13·3
Olivine . . .	18·5	18·5	1·7
Ilmenite . . .	3·6	4·0	—
Magnetite . .	—	—	6·3
Pyrite . . .	·2	·2	—
Apatite . . .	1·3	1·3	2·4
Orthoclase . .	1·1	1·1	8·9
Albite . . .	9·4	10·5	24·4
Anorthite . .	32·5	29·2	—
Nepheline . .	—	3·1	10·4
Analcite . . .	—	—	12·0
Water, Alteration Products, etc. .	6·0	6·0	5·4
	101·0	100·6	99·9

I. Bekinkinite. Barshaw.
II. Bekinkinite. Barshaw. Second calculation.
III. Lugarite. Barshaw.

Analyses of titanaugite from Crawfordjohn, and of barkevikite from Lugar, were used in Nos. I and III; in No. II an analysis of augite from monchiquite of Serra de Tingua, Brazil (analysis *q* of table xii, Cross, Iddings, Pirsson, and Washington, *Quantitative Classification of Igneous Rocks*, 1902) was used in place of the Crawfordjohn titanaugite.

Comparing Tables II and III, it is evident that the mineral composition of the bekinkinite, as obtained by calculation from the chemical analysis, does not agree well with the micrometric analysis. The greatest difference is in the relative amounts of the light and dark minerals. The chemical analysis gives a much more leucocratic type than does the micrometric analysis, and, moreover, provides no nepheline or analcite. These discrepancies may arise from three causes: the assumptions made as to the chemical composition of the constituent minerals may not be correct; the chemical analysis may be incorrect; or the rock analysed by the Survey may not be identical with the one investigated in this paper. In connexion with the first-mentioned, a calculation of the mineral composition utilizing the analysis of a Brazilian augite gave better results in so far as it was possible to obtain a little nepheline (No. II, Table III), but the relative amounts of the light and dark constituents remain much the same as before. The second hypothesis may be dismissed as improbable in view of the high quality of the Survey analyses. It is more probable that, assuming the accuracy of the analyses, the discrepancy between the results obtained by the two methods arises from the fact that the rock analysed by the Survey evidently contained little or no nepheline, and was rich in the anorthite molecule, thus differing from the type described in this paper. The amount of lime and alumina in the analysis is much in excess of that required for the bisilicate minerals, and could only go into anorthite.

For the lugarite, however, there is a satisfactory agreement between the results of the two methods of analysis. In the calculation of mineral composition from the chemical analysis it was assumed that ægirine and olivine were present in the amounts fixed by those of the norm, and that analcite totalled 12 per cent. The result of the calculation shows that these assumptions were justified. The calculated mineral composition agrees best with varieties 1 and 2 (Nos. I, II, and III of Table II). In the one case there is an excess of pyroxene, in the other an excess of barkevikite in the micrometric analysis as compared with the quantities of these minerals in the calculated mineral composition. It is probable, however, that the rock analysed contained both types of lugarite, and that the chemical analysis therefore represents a mixture of these two types. The quantitative relations of titanaugite and barkevikite vary considerably, even within the limits of a single thin section.

There are one or two minor discrepancies. For example, no anorthite can be calculated out of the chemical analysis on the assumptions made, although the anorthite molecule must be present in small amount. Moreover, the percentage of TiO_2 in the analysis is too small to allow any ilmenite to be calculated after titanaugite and barkevikite have been satisfied in this constituent. As ilmenite is undoubtedly present, the above minerals must either be poorer in titania than assumed, or the analysis must be defective in this particular. In spite of these discrepancies the agreement between the calculated and the measured modes may be taken as good, making all allowance for disturbance caused by the alteration of some of the constituents of the rock.

It is interesting to compare the relative amounts of the felsic [1] and mafic minerals, as shown in Tables II and III.

	Felsic.	Mafic.	$\frac{F}{M}$ ratio.	
Bekinkinite (Table II, col. VI) . .	30·7	69·3	·44	Domafic
Bekinkinite (Table III, col. I) . .	49·0	52·0	·94	Mafelsic
Bekinkinite (Table III, col. II) . .	49·9	50·7	·98	Mafelsic
Lugarite, var. 1 (Table II, col. I) .	53·9	46·1	1·17	Mafelsic
Lugarite, var. 2 (Table II, col. II) .	51·9	48·1	1·08	Mafelsic
Lugarite, var. 2 (Table II, col. III) .	55·0	45·0	1·22	Mafelsic
Lugarite, var. 3 (Table II, col. IV) .	80·6	19·4	4·15	Dofelsic

VII.—A Contribution to the Petrology of North-Western Angola.

By Arthur Holmes, B.Sc., A.R.C.S., F.G.S., F.R.G.S.

(*Concluded from the July Number, p. 328.*)

Olivine ulrichite. — Megascopically this rock differs from the foregoing nepheline monchiquite in having a well-marked porphyritic structure, the phenocrysts including orthoclase and nepheline in crystals having a maximum dimension of nearly a centimetre. Under the microscope the minerals present are:—

Phenocrysts.		*Groundmass.*
Nepheline.	Titaniferous augite.	Anorthoclase.
Sanidine.	Ægirine-augite.	Amphiboles.
Anorthoclase.	Ægirine.	Pyroxenes.
Barkevikite.	Olivine and serpentine.	Calcite.
Arfvedsonite.	Analcime.	Apatite.
Augite.		Iron-ores.

Nepheline and *sanidine* call for no special description. *Anorthoclase* is similar to that in the phonolites. The anorthoclase of the groundmass, in small prisms arranged at various angles, was determined by its optical characters and specific gravity.

[1] The terms *felsic* and *mafic* have been proposed by Cross, Iddings, Pirsson, and Washington (*Journ. Geol.*, xx, p. 560, 1912) as names for two main groups of rock-forming minerals, the one including quartz, felspars, and felspathoids; the other, pyroxenes, amphiboles, micas, olivine, iron-ores, etc. Variation in the relative proportions of these two groups constitutes the important mode of variation in igneous rocks which gives rise to leucocratic, mesocratic, and melanocratic types. A quantitative expression may be given to this variation by attaching the prefixes *per-* and *do-* to the terms *felsic* and *mafic*, with a similar connotation in respect to the mode as the analogous terms persalic, dosalic, etc., have in respect to the norm of the American Quantitative Classification.

perfelsic . . .	$\frac{\text{felsic}}{\text{mafic}} > \frac{7}{1}$	leucocratic types.
dofelsic . . .	,, $< \frac{7}{1} > \frac{5}{3}$	leucocratic types.
mafelsic . . .	,, $< \frac{5}{3} > \frac{3}{5}$	mesocratic types.
domafic . . .	,, $< \frac{3}{5} > \frac{1}{7}$	melanocratic types.
permafic . . .	,, $< \frac{1}{7}$	melanocratic types.

Analcime is seen in roughly circular spaces, surrounded by the coloured minerals, some of which are arranged at sharp angles suggesting the trapezohedron form. This mineral is more abundant as phenocrysts than in the nepheline monchiquite, but seems to be absent from the groundmass.

The chief amphibole present is barkevikite, which differs from that of the nepheline monchiquite only in having somewhat darker colours. A little arfvedsonite is associated with it. The pyroxene series, again, is very similar to that already described (p. 324), except that the titaniferous augites are larger and more independent of the ægirine-augites. Another difference lies in the absence of long wisp-like growths, stout prisms of all sizes up to 1 mm. being the chief habit developed.

The rock differs sharply from the nepheline monchiquite in the total absence of sphene and in the presence of phenocrysts of olivine. These are about the same size as the larger titaniferous augites, averaging 1 mm. in length. Idiomorphic forms are rare, and the crystals have been altered to serpentine along numerous cracks and around the borders. Many of the crystals are surrounded by small prisms of barkevikite and ægirine-augite.

Although the rock has not been analysed, it bears so close a mineralogical resemblance to the ulrichite of Dunedin, New Zealand,[1] that the writer has no hesitation in applying to it the same name. Ulrichite seems to occupy the same position among the dyke rocks as canadite, recently defined by Quensel,[2] holds among the plutonic rocks. Canadite is a nepheline syenite, rich in mafic minerals, and containing normative lime-soda felspar, which does not necessarily appear in the mode of the rock. Ulrichite may be defined in the same way with reference to the tinguaites, and as already discussed in the case of monchiquites; it would save much confusion to retain the term ulrichite for olivine-free varieties, and describe those containing olivine as *olivine ulrichite*.

Nepheline phonolite (grey).—Megascopically the rock consists of a green-grey aphanitic groundmass in which large tabular phenocrysts of nepheline and sanidine are distributed. The former are of a yellow colour with an occasional reddish hue, and may reach a length of 1 inch. The sanidines are thin and glassy, and exhibit Carlsbad twinning; they rarely exceed ½ inch in length. On the weathered surface long ridges of nepheline stand out above the less resistant groundmass. Under the microscope, the following minerals are seen to be present:—

Phenocrysts.	*Groundmass.*
Nepheline.	Anorthoclase and nepheline.
Sanidine (with inclusions of albite and a mineral of the sodalite group).	Ægirine and ægirine-augite.
Anorthoclase.	Calcite.
Ægirine-augite.	Iron-ores.
Analcime.	Brown decomposition products.
	Isotropic base probably consisting of analcime.

Almost all the *sanidine* phenocrysts contain rhomb-shaped

[1] P. Marshall, Q.J.G.S., lxii, p. 397, 1906.
[2] P. Quensel, Bull. Geol. Inst. Upsala, xii, p. 130, 1914.

inclusions of albite, some of which show lamellar twinning. There are also inclusions of a clear and colourless mineral having a much lower refractive index than orthoclase. The inclusions are idiomorphic and present four- or six-sided sections, some of the latter being elongated in one direction. These features point to their belonging to the sodalite group, but further identification is not possible on account of the minuteness of the individuals.

The phenocrysts of *anorthoclase* differ from those of sanidine in being smaller in their dimensions, in having a slightly higher refractive index, more obscure boundaries, minute twin striations, and a mottled extinction.

Nepheline is not abundant except as large crystals, and very tiny ones which enter into the make-up of the groundmass. It is noteworthy, in view of the presence of cancrinite in the associated dyke rocks and nepheline syenite, to notice its absence both from this and the brown phonolite. A small phenocryst of *analcime* was seen in one section attached to a nepheline.

Ægirine-augite is rare as phenocrysts, but in short needles and grains in the groundmass it is abundant. Needles and flakes of ægirine are also present, the extinction being nearly straight, and the pleochroism strong in tints of yellow-brown, yellow-green, and blue-green. Amphiboles are entirely absent, though there are numerous ragged shreds and aggregates of a brown decomposition product, which may represent some variety of hornblende. Laths of nepheline and anorthoclase can be distinguished in the groundmass, and interspersed between them and the pyroxenes is a clear glassy isotropic base, which may be glass or analcime.

The rock was crushed, and the material which floated in bromoform diluted with benzine to give a liquid of specific gravity 2·28, was collected. Most of the grains were completely isotropic, and after washing and drying, their refractive index was found to lie between those of castor-oil (1·48) and xylol (1·495). These details, together with the fact that the rock contains over 2 per cent of combined water, point to the identity of the isotropic base with analcime, or with a glass of similar composition. While no signs of crystalline structures on the one hand, or of devitrification or flow-structures on the other, can be discerned, the exact nature of the base must remain in doubt, though its correspondence in all essential respects with the analcime phenocrysts of the associated ulrichite throws the balance of evidence in favour of its being *analcime*.

Nepheline phonolite (brown).[1]—In this rock the phenocrysts are smaller than those of the preceding, but nepheline in good idiomorphic crystals is much more abundant, while orthoclase is subordinate. The minerals present are as follows:—

Phenocrysts.	*Groundmass.*
Nepheline.	Anorthoclase and nepheline.
Sanidine (with inclusions of albite and calcite).	Ægirine and ægirine-augite.
Anorthoclase.	Iron-ores.
Ægirine-augite.	Isotropic base with calcite and indeterminate brown pleochroic patches.

[1] Pl. XI, Fig. 4.

Among the phenocrysts, those of *nepheline* differ from those in the grey phonolite only in size, and in having numerous inclusions of tiny laths of ægirine, arranged in rows, just within and parallel to their borders. *Anorthoclase*, as before, is present in long, narrow, vaguely outlined laths. The *sanidines* are free from inclusions of a sodalite-like mineral, but irregular patches and streaks of *calcite* and of the brownish glassy base are common.

Ægirine-augite occurs in dark-green, spongy crystals, in ragged shreds and patches, and to a less extent in small needles and tufts. The *groundmass* is yellow to brown in colour, and is frequently broken by tiny laths, often radiating from a common centre, of anorthoclase and nepheline, and by granular masses and blebs of calcite. The latter does not appear to be the result of alteration by weathering, and its presence with glass in the felspar phenocrysts suggests the view that it is an original product of the magma from which the rock was formed. It is noteworthy that cancrinite is present in the rocks described in the July number, and the calcium carbonate of that mineral may be here represented as free calcite.

The greater part of the base is isotropic, but there are a few pleochroic (yellow to brown) areas of indefinite form. They may represent a phase in the magmatic decay of hornblende under superficial conditions, for otherwise this mineral is not represented in the volcanic rocks.

Summary and General Considerations.—In the following table the mineralogical constituents of the five rocks described are summarized and their specific gravities are added :—

Mineral.	Nepheline Syenite (Foyaite).	Nepheline Monchiquite.	Olivine Ulrichite.	Nepheline Phonolite (grey).	Nepheline Phonolite (brown).
Nepheline	x	x	x	x	x
Cancrinite	x	x	–	–	–
Calcite	–	–	x	x	x
Analcime or isotropic base	–	x	x	x	x
Anorthoclase	–	–	x	x	x
Perthite	x	–	–	–	–
Orthoclase or sanidine	x	–	x	x	x
Barkevikite	–	x	x	represented by decomposition products?	
Arfvedsonite	x	x	x		
Hastingsite	x	x	–		
Augite	x	x	x	–	–
Titaniferous augite	x	x	x	–	–
Ægirine-augite	x	x	x	x	x
Ægirine	x	x	x	x	x
Ilmenite and magnetite	x	x	x	x	x
Sphene	x	x	–	–	–
Olivine	–	–	x	–	–
Biotite	x	–	–	–	–
Zircon	x	–	–	–	–
Sp.gr.	2·60	2·67	2·72	2·47	2·56

The whole suite of rocks is characterized by a common association of minerals. The absence of analcime from the foyaite and of cancrinite and amphiboles from the phonolites is entirely consistent with the usual behaviour of these minerals under the varying conditions which control the crystallization of magmas. Calcite is present in the phonolites and in the olivine ulrichite in precisely the same way as cancrinite occurs in the other rocks. Amphiboles, recognizable as such, are absent from the phonolites, but decomposition products which may well be their representatives, still remain. There is, therefore, strong mineralogical evidence pointing to consanguinity and differentiation from a common magma. The rocks differ chiefly in the relative proportions of the minerals present, and in the structures determined by those proportions and by the mode of crystallization. The only exceptions to this are found in the isolated occurrence of olivine in olivine ulrichite and in the absence of sphene from that rock and from the phonolites. With these exceptions the foyaite and the nepheline monchiquite clearly represent leucocratic and melanocratic phases respectively of an original magma which may be closely approximated to by the phonolites. In the absence of field evidence as to the relative abundance and order of intrusion, it is not yet possible to go further in the attempt to elucidate the origin of the various rock-types.

No basaltic rocks were collected by Colonel Andrade, but near the old fort of Duque de Bragança (lat. 9° S., long. 16° E.), which is not far from the road between Senza and Bango, M. John Monteiro discovered in 1875 [1] a series of trachytes and of porphyritic basalts, which still await description.

With the exception of a brief note by M. Pereira de Sousa in 1913, there has hitherto been no published record of nepheline-bearing rocks in South-West Africa between Namaqualand and the Kamerun. Nepheline syenites and phonolites, with associated intrusions of a barkevikite-bearing monchiquite, occur near Pomona, just to the north of the Orange River.[2] Nepheline syenite has also been found to the west of Kamerun Mountain, and in the Benue Valley between Yola and Garua in Adamaua,[3] associated in the latter locality with nepheline basalts and phonolites. The suite of nepheline rocks described in this paper falls midway between Pomona and Kamerun, and the gap has now been further bridged by Professor J. W. Gregory's discovery of a similar suite of rocks at Chiucca in the province of Benguela, where alkaline volcanics occur in association with solvsbergite and shonkinite.

[1] P. Choffat, Mém. de la Soc. Phys. et d'Hist. Nat. de Genève, xxx, No. 2, 1888.

[2] See also Kaiser, in Bibliographie Géol. du Portugal et de ses colonies, ser. II, 1913, p. 21.

[3] Passarge, *Adamaua*, 1895, p. 384.

REVIEWS.

I.—Museum of Practical Geology.

A Handbook to the Collection of Kaolin, China-clay, and China-stone in the Museum of Practical Geology, Jermyn Street, London, S.W. By J. Allen Howe, B.Sc., F.G.S., Curator. With an Appendix by Allan B. Dick. pp. viii, 271, pls. ix. London: Darling & Son, Ltd., 1914. Price 3*s.* 6*d.*

IT is a curious technological fact that our knowledge of the constitution of many materials which owing to their useful properties have acquired an extended application is decidedly limited. Bleaching powder and Portland cement might be cited as examples among inorganic materials, and india-rubber among organic substances. A large amount of investigation has been directed towards elucidating the constitution of bleaching powder, the chemical changes that occur during the setting and hardening of cement, and to the isolation of the various constituents which collectively form india-rubber, but it can hardly be said that the last word has been uttered on these problems.

The handbook now under review contains ample evidence that we do not fully comprehend either the mode of origin or the constitution of the essential raw material of what is credited with being the most ancient of the arts. Though nominally a handbook to the collection of Kaolin, China-clay, and China-stone in the Museum of Practical Geology, the volume would be far more accurately described as a valuable guide to the study of Clays, and contains information of service not only to the geologist and clay-worker but to many other classes of inquirers.

The introduction and chapters iv and v give a brief account of the nature and uses of china-clay and china-stone. The second chapter, describing the discovery, development, and method of mining the famous deposits of Cornwall and Devon, contains matter interesting not only to the general reader but also to those more directly connected with the industry. The inclusion of this chapter is particularly serviceable, since it covers the ground of *A Treatise on China Clay*, written by David Cock more than thirty years ago, which, unfortunately, is out of print and scarce. Chapter iii has given to English readers an account of the distribution of kaolins all over the world, which certainly has never been easily accessible hitherto. Chapter vi affords a very fairly complete survey of our present knowledge of some of the physical characters and chemical constitution of kaolinite and several minerals allied to it.

Chapter vii, on the origin of kaolin, will naturally appeal most strongly to the geologist, and certainly affords him an excellent and critical examination of the various theories that have been advanced to account for the existence of china-clay rock. This fascinating problem is by no means as simple as it might at first appear. The simple explanation, found in all textbooks on geology, of the process

by which the felspars of solid granitic masses have been converted into friable, white kaolin, though possibly sufficient in a few cases, has long been recognized as incomplete, especially by those acquainted with the deposits of Cornwall and Devon. Two or three facts may be mentioned here, of which the ordinary theory of 'surface weathering' does not seem to afford a satisfactory explanation. For instance, the existence of extensive tracts of unaltered granitic rock in many localities at once indicates that the decomposing action of water and carbon dioxide on felspar is not universal, and it would not seem unfair to throw on the advocates of this theory of kaolinization the onus of explaining what factors have been operative in causing this selective action on the part of the decomposing agents. That kaolin would be easily and quickly removed by the ordinary agents of denudation is not a sufficient explanation, for then such granitic masses as those referred to would show signs of erosion where the kaolinized material had been removed. From a purely chemical point of view, too, the ordinary theory of weathering does not make at all clear by what mechanism two molecules of chemically combined water became an integral part of the argillaceous compound. A satisfactory explanation of this process may reasonably be demanded of any theory of kaolinization, especially in view of the fact that water can only be reintroduced into a dehydrated clay with the greatest difficulty, even if at all. At the same time it must be frankly admitted that the chemistry of the conversion of felspar into kaolin is very complex, and it is perhaps not too much to say that no theory of kaolinization at present propounded affords a complete explanation of all the reactions involved. There seems no doubt that during the decomposition of the original rock a number of secondary minerals had been formed, and consequently a number of secondary chemical reactions must have occurred, which only increase the difficulty of tracing the stages by which felspar has been converted into kaolin. The depth to which the deposits extend and the improvement in quality—in other words the more complete kaolinization—which is often found with increasing depth, are phenomena that certainly lend strong support to the theory that in such areas the action has passed from below upwards. The advocates of particular theories have perhaps been over ardent in support of their own pet theory and prone to disregard the value of others. Certainly a perusal of the evidence given in these pages, supported as it is by copious references to original papers, is enough to show that the problem cannot be said to be solved, and it was a happy inspiration which led the author of the handbook to conclude his summary of the theories with the quotation from F. W. Clarke: "Kaolin, like many other substances, may be formed by any one of several processes, in all of which water, hot or cold, and carbonic acid take part. No one interpretation can fit all its occurrences."

The details of composition and various physical properties of china-clays from many localities, in chapter viii, together with the statistics and list of china-clay works in England, are most useful additions, brought together in compact form, so far as we can remember, for the first time.

No remarks on this handbook would be complete without reference to Appendix 1, from the pen of Mr. Allan B. Dick, which describes a novel way of examining mineral fragments under the microscope, in especially selected media of requisite refractive indices, with dark ground illumination. Only those who have had the advantage of seeing the method in operation can fully appreciate its beauty and the ease with which kaolinite crystals can be detected, and it is to be hoped that the method will find considerable application in that very difficult region of investigation, the microscopic examination of clays.

In 1893 the handbook to the Collection of British Pottery and Porcelain at Jermyn Street was issued and formed the first of the series of handbooks that replaced mere catalogues. The valuable notes on British Clays compiled by Mr. George Maw were included in that volume, and a worthy successor to it has been found in the handbook under review, which forms the second publication on clays issued from the Museum of Practical Geology. Information with regard to clays is scattered and often inaccessible, and it is to be regretted that greater advantage is not taken of such publications as those just mentioned. Textbooks on geology and chemistry give almost nothing, and anyone wishing to get an insight into the properties of clays could hardly be better advised than to read these handbooks. The study of clays has not received the attention it deserves, and the fact is often overlooked that the output of clays, together with the closely allied material, shale, in this country is only exceeded by two other mineral products, coal and iron-ores. Though a large portion may be of relatively low value, still clay is the essential constituent of products which range from an exquisite work of art to a common building brick, and without refractory clays hardly a single manufacture could exist.

In conclusion, the author is to be congratulated on having attained two dissimilar objects in one volume with marked success; the general visitor to the Museum is provided with an interesting handbook, and the specialist with a valuable scientific textbook. Kaolin might perhaps be described as the fundamental or parent clay, but owing to the remarkably complete series of geological formations represented in this country, we have many deposits of great economic value which supply raw material for all branches of ceramic manufacture, such as ball clays, stoneware clays, and fire-clays. Consequently it would seem that the authorities at the Museum of Practical Geology would be fulfilling the mandate received in 1835 "to form collections illustrative of the mineral wealth of the country and of the applications of its various mineral substances to the useful purposes of life", if the present handbook were followed up by others, dealing with the special and more important classes of clays such as those just mentioned, and gigantic though the task might be it is not too much to say that its execution could not be in better hands than those of the present Curator.

W. C. H.

II.—Geological Survey of New Zealand.

Revision of the Tertiary Mollusca of New Zealand, based on Type-material. Part I. By Henry Suter. Palæontological Bulletin, No. 2, New Zealand Geological Survey (P. C. Morgan, Director). 4to; pp. 64, pls. i–xvii, with a transmittal letter by P. G. Morgan and a preface by J. Allan Thomson. Wellington, 1914.

THE authorities of the New Zealand Geological Survey are to be congratulated on having secured the services of so well known a conchologist as Mr. Henry Suter, member of the Malacological Society of London, to undertake the revision of their Tertiary Mollusca from that country. His long experience as a student and a writer of the living shells of New Zealand has specially fitted him to accomplish so important and necessary a task.

As a first fasciculus in this direction the present memoir deals entirely with the type-material which formed the basis of the late Captain F. W. Hutton's *Catalogue of the Tertiary Mollusca and Echinodermata of New Zealand in the Collection of the Colonial Museum*, published in 1873, a revision of which has been long required from the fact that it included a number of brief diagnoses of new species without the support of illustrations, although certain "lithographed plates" were promised to be "issued shortly" in a preface written to the work by the late Sir James Hector, which, however, were never forthcoming. Some of these new species were subsequently figured by Hutton in his monograph on *The Pliocene Mollusca of New Zealand*, which formed part of "The Macleay Memorial Volume", issued under the auspices of the Linnean Society of New South Wales in 1893. Since that date palæontologists have been mainly indebted for any further knowledge of the subject to the writings of the late Mr. G. F. Harris, whose excellent treatise on *The Australasian Tertiary Mollusca in the British Museum*, published during 1897, included several forms from New Zealand. In addition to such memoirs it must not be forgotten that many species of New Zealand Tertiary Mollusca had been previously described and figured by the late Professor von Zittel in his *Fossile Mollusken und Echinodermen aus Neu-Seeland*, forming vol. i of the "Novara Expedition" report of 1864. In this connexion Zittel's researches were of peculiar geological interest because, from a study of the palæontological works of G. B. Sowerby and Alcide d'Orbigny on South America, he was able to trace a resemblance between the Tertiary faunas of New Zealand and those of Chili and Patagonia, the existence of such a relationship having been strongly supported since by Dr. Ortmann and the later specialists who met recently in Australia to discuss this and sundry matters appertaining to the age of the Lower Tertiary rocks of Australasia.

A considerable reduction in the number of molluscan species has been the outcome of this revision, Mr. Suter having recognized 101 species and varieties, consisting of 44 Gastropoda, 3 Scaphopoda, and 54 Pelecypoda, as against Hutton's estimate of 275 species, made up of 127 Gastropoda, 9 Scaphopoda, and 139 Pelecypoda—a result

which should be welcome to all students of the Tertiary shells of New Zealand as tending to simplify a somewhat complicated subject. The author contributes carefully prepared diagnoses of the species, but has failed to include the original descriptions as given in the Hutton Catalogue: had that been done we should have been better able to institute comparisons between the old and the new determinations, a plan which, we think, would have rendered the *Revision* of greater historical and scientific importance.

The generic nomenclature adopted in the work appears to be generally on an up-to-date basis, as an instance of which we may observe that *Turris* of Bolten is used to the exclusion of Lamarck's *Pleurotoma*, the former finding a place in Gray's Catalogue of 1847, although since that time the name has been more commonly adopted by American rather than by British conchologists. Attention may here be directed to one of the Pelecypod determinations—*Pecten* (*Camptonectes*) *huttoni*. This is a true *Pseudamussium*, as long since acknowledged both by G. F. Harris and Professor Park, and therefore quite distinct from Meek's *Camptonectes*, which is a characteristic genus of the Mesozoic period, possessing very unequal auricles as in *Chlamys*, and furnished with divergent, bifurcating, and punctated striations which are more or less obsolete over the umbonal half of the valve.

It is to be regretted that the geological information is of so meagre a description. We could have wished that a scheme of the fossiliferous marine Tertiaries of New Zealand had been inserted for the benefit of the student, together with a good topographical map. In the meantime we may here generally state that the Tertiary rocks of New Zealand are recognized as being divisible into two great groups —the Oamaru and the Wanganui, the former, comprising the Pareora, Waihao, and some other Series, being of Miocene age, whereas the Wanganui rocks belong to the Pliocene system, and embrace the Petane, Waitotara, and Awatere Series. From the horizons that accompany the specific descriptions we gather that the author regards the older Tertiary beds of New Zealand as of Miocene age, and not Eocene as was formerly supposed, this being in agreement with the strictest modern views that there are no true marine Eocene deposits throughout Australasia. Finally, this work is excellently printed and illustrated with good photographic plates, while the genera and species are most completely indexed. We shall look forward with much pleasure to a later fasciculus which is promised, and which is to contain a revision of the specific types of New Zealand Tertiary Mollusca established since 1873.

R. B. N.

III.—Tertiary Echinoids from the San Pablo Group of Middle California. By William S. W. Kew. Univ. California Publ. Geol., vol. viii, No. 20, March 2, 1915. pp. 365–76, pls. xxxix–xl.

OF the variability of the Clypeastroids there is no end, and of the torrent of species thereof described there is little sign of diminution. From the number of intrapetaloid tubercles that have

escaped denudation, to the fourth place of decimals of the proportionate length of a petal, each and every detail seems to suffice for specific separation. Surely one of the first and most essential parts of the curriculum of a larval systematic palæontologist should induce him to collect, measure, and specifically distinguish every several leaf from a well-grown tree. After such preliminary training, the ardour of the image might be appreciably subdued.

The present paper has two distinct merits above many of its kind. Only two new species and two smaller divisions are named; and a concise index to their relative stratigraphical occurrence is supplied. But the characters on which the specific and varietal divisions are made do not appear to be of great importance, and no attempt is made to demonstrate their meaning, if any. The latter criticism may well be answered by the explanation that sufficient material is not yet available; but such an excuse would tend to suggest that the whole matter might be left alone until such material has been collected.

In two long-ranged forms like *Scutella gabbi* and *Astrodapsis tumidus* there will be, in all probability, a progressive series of modifications into well-marked directions. Until the trend of the variation can be postulated, would it not be safer to defer the introduction of new names which have no certain biological significance, and which may lead even stratigraphers astray?

H. L. H.

IV.—The American Journal of Science.

VOL. XXXIX of the *American Journal of Science*, 1915, contains three important papers emanating from the Carnegie Institute and dealing with the crystallization, under laboratory conditions, of certain silicate mixtures. The first, by Mr. C. A. Rankin, describes the ternary system lime-alumina-silica. Although the compounds of these substances show no solid solutions, nevertheless the relations are very complex, owing to the large number of minerals that are possible: these are quartz, tridymite, cristobalite, corundum, wollastonite, sillimanite, and anorthite, together with several calcium silicates not known to occur in nature. The equilibrium diagram contains no less than fourteen separate fields. The chief application of the results is to the study of Portland cement. A subsidiary point of geological interest is the observation that eutectics of silicates have in general no structure differing from that of other mixtures, except that they are very fine in grain. This is of some significance in connexion with certain igneous rocks. In another paper Mr. Olaf Andersen describes the system anorthite-forsterite-silica. In some mixtures spinel is found to be a primary phase, while in others the unstable substance clino-enstatite is formed. This is not a true ternary system and can only be expressed in terms of the four-component system lime-magnesia-alumina-silica. It is shown that under certain conditions forsterite undergoes resorption without any change of physical environment, a fact which has an important bearing on the magmatic resorption of olivine in certain peridotites and anorthite rocks. When the olivine becomes surrounded by a shell of its

decomposition products, quartz and olivine may be found in the same rock. Mr. N. L. Bowen discusses crystallization-differentiation in silicate liquids and shows experimentally that crystals sink with considerable rapidity in artificial melts. Hence this process may be of importance in the differentiation of igneous magmas.—R. H. R.

V.—The Petroleum Occurrences of Assam and Bengal. By E. H. Pascoe, M.A., D.Sc. Mem. Geol. Surv. India, vol. xl, pt. ii.

THE present volume forms a fitting sequel to the author's recent work on the Oil-fields of Burma, which has made Further Indian oil-fields better understood than many of those in Europe and America.

The Coal-measures series in which the oil occurs is almost certainly the homotaxial equivalent of the Pegu Beds of Burma. They are underlain by the Nummulitic Series, while the overlying Tipam Sandstones are very similar to the Irrawadi Beds. It would appear that whereas the Burma oil-fields occur in the Hinterland behind the region of maximum mountain-building movement, those of Assam form a belt in the Forland a little to the west of the great boundary thrust, and have suffered more intense folding. The author infers overfolding in each of the main oil-fields, and although the poor exposures and dense forest render the matter difficult of proof, the balance of evidence appears to favour this view. The folding is probably accompanied by thrusting, and the structures produced are very similar to those of some of the Carpathian oil-fields.

Another point of interest is the supposed interference of the Himalayan and Burmese movements in the north-eastern portion of the area. The close association of oil and coal, and the sparsity of animal remains, certainly support the views of the geologists of Burma, that in these beds of Further India the natural hydrocarbons are mainly of vegetable origin.

VI.—Brief Notices.

1. Earthquakes in Burma.—In the month of May, 1912, Burma was visited by severe earthquakes, which culminated in a great shock on the morning of May 23. This was sensible over an area of 375,000 square miles, and caused much damage in Mandalay, Maymyo, and other places, though attended by little or no loss of life, owing to the character of the buildings. This shock is described in detail by Mr. J. Coggin Brown (Mem. Geol. Surv. India, vol. xlii, pt. i). In the central part of the area the shock reached the intensity of ix on the Rossi-Forel scale, although this isoseist could not be exactly delimited; the other isoseists had an elliptical form, with their long axes running north and south. The position of this long axis coincided very nearly with the great Kyaukkyan fault, described by Mr. La Touche as one of the most notable features of Burmese geology; the railway was bent where it crosses this fault, but unaffected where it crosses the other faults of the plateau. No actual surface displacement was anywhere observed.

2. Ferberite in Colorado.—The rare mineral ferberite occurs in workable quantities in Boulder County, Colorado. An exhaustive account is given by Messrs. Hess & Schaller (Bulletin 583, United States Geological Survey, 1914). The end members of the wolframite series are ferberite, $FeWO_4$, and hübnerite, $MnWO_4$; wolframite is an isomorphous mixture of these two compounds. The ferberite of Boulder County occurs in beautifully developed, though small crystals, some of a wedge shape, others of almost cubic habit; also massive and in blades. They are black, almost metallic, and opaque in thin sections. All known analyses of the wolframite group are tabulated and criticized, and an appendix contains an elaborate crystallographic discussion.

3. Bulletin 577 of the United States Geological Survey contains a very full description of the geology of the phosphate deposits north-east of Georgetown, Idaho, by Messrs. R. W. Richards and G. R. Mansfield. The phosphate-bearing rock is an oolitic sediment associated with limestones, and probably of Permian age: near the outcrops it seems to have undergone secondary enrichment by weathering. Average samples generally show about 32 per cent of phosphoric acid, and the amount of rock available is estimated at more than 2,500,000,000 tons. The geological structure of the district is very complicated, including an overthrust which has carried Carboniferous rocks for a distance of some 12 miles over Cretaceous and Eocene strata: consequently in places the phosphate beds are buried too deeply to be worked. No satisfactory explanation of the origin of the phosphatization is forthcoming.

4. In the Bulletin of the Geological Society of America, vol. xxv, pp. 277–320, 1914, Mr. Charles Schuchert describes his work on the Medina and Cataract formations of New York and Ontario. It is shown that the Cataract formation of Ontario, formerly ascribed to the Clinton, is really equivalent to the typical Medina of New York, while the Brassfield Beds of Ohio are of about the same age. The variations are due to deposition in marine areas with only limited connexion, encroaching from different directions. The Medina is essentially a sandstone facies, while the others are calcareous. The second part of the paper contains an historical review of research on these rocks, together with full descriptions of sections and lists of fossils.—R. H. R.

5. North American Geology.—The valuable Bibliography of North American Geology has appeared for 1913. It is compiled and indexed by J. M. Nickles and is a model of what such publications should be. It includes all papers on the North American Continent and adjoining islands, as well as Panama and the Hawaiian Islands. There are 1,357 items.

6. Potash in the Texas Permian.—The impossibility of securing shipment from Germany of potash has led the Texan Bureau of Economic Geology to investigate the sources of supply in that State. The results are highly satisfactory, and Mr. J. A. Udden has issued a detailed report in the Bull. Univ. Texas, 1915, No. 17.

7. Rhodesia Museum, Department of Geology.—Owing to the departure of Mr. Macgregor for England in February, 1915, a detailed account of the progress of the Geological Department during the past

year cannot be included in the report for 1914. A considerable amount of work has been done within the year, in spite of the serious hindrance to development due to the lack of cases and room. In addition to arranging and classifying the present collections and additions received during the year, much of Mr. Macgregor's time has been absorbed in making determinations for the public. Fifty-seven such determinations were carried out, including twenty-three rock-slides, besides a number of determinations at sight. Two collecting trips were made by Mr. Macgregor—one to Shiloh, for the purpose of searching for fossils of the Forest Sandstone formation, the other to the Bembesi Diamond Field and Somabula and Victoria districts. Although no success attended the first of these journeys, the second resulted in the acquisition of many valuable mineral and rock specimens.

8. Anticosti Island.—This island consists of a part of a cuesta on an ancient coastal plain which probably began to develop in the Devonian and existed until the time of the post-glacial submergence. It will be called the Anticosti cuesta. About 20 miles to the north the Mingan Islands fringe the Quebec shore and consist of the remnants of a parallel cuesta. This will be named the Mingan cuesta. Between the two cuestas lay an inner lowland which near the west end of Anticosti was crossed by a north–south divide from which streams drained east and west, the former being the larger. North of the Mingan cuesta is another lowland. The latter will be called the Laurentide lowland and the former the Channel lowland. In these words Mr. Twenhofel (Canada, Dept. Mines, Mus. Bull., No. 3, 1914) describes the structure of Anticosti Island, and then proceeds to give faunal summaries of the various formations for the Ordovician and Silurian systems. He describes a few new species of fossils, and promises an exhaustive memoir on the geology and palæontology later.

9. Leeds.—The activity of the Leeds Geological Association may be gathered from the last number of the Transactions (part xvii, 1911–13, November, 1914). Miss S. E. Chapman writes on "Some Petrological Characteristics of Underclays"; Mr. C. Thompson, "Ammonites of the Lias"; P. F. Kendall, "Evidences of Climatic Changes in Geological Times"; Burnet & Everett, "Sections in a Quarry at Robin Hood, near Leeds", in the Middle Coal-measures. Many excellent photographs and quite a good list of plants accompany this last paper.

10. *Beatricea.*—This very old friend and puzzle to the palæontologist has turned up in the Middle Ordovician of South Pennsylvania. It was first noticed there by Ulrich in 1908, and P. E. Raymond has seen the specimens and described them in detail in Canada, Dept. Mines, Mus. Bull., No. 5, 1914. Raymond gives very fine photographic sections, and though he inclines to the Stromatoporoid view of their relationships he cautiously refers to them as "early Palæozoic organisms". Moreover, he does not consider that Ulrich's specimens are true *Beatricea*, and proposes for them the new generic and specific name of *Cryptophragmus antiquatus*. Mr. Raymond has done good service in presenting us with such excellent figures for study.

11. Jurassic Brachiopoda.—In June, 1914, Mr. S. S. Buckman, who has been working for some years on a large series of Brachiopoda from Burma, issued a single sheet (through Messrs. Wesley & Son) of new generic names, to which he attached the name of the genotypes. This he circulated freely with No. xiv of his "Yorkshire Type Ammonites", June, 1914, and now (May, 1915) the same with additional matter appears in his "Brachiopoda of the Namyall Beds of Burma" (Records Geol. Surv. India, xiv, pt. i), which is a preliminary notice of a monograph now in course of printing in the *Palæontologica Indica*.

While opinions may differ as to the advantages of these preliminary notices, it is only fair to point out that, with so many workers in the same field, 'cutting out' is as often due to the dilatoriness of the original author as to the want of honour in a rival. No one has the right to hold up ideas that have been ventilated in conversation, to the hindrance of scientific progress.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

June 23, 1915.—Dr. A. Smith Woodward, F.R.S., President, in the Chair.

The following communications were read:—

1. "On a New Eurypterid from the Belgian Coal-measures." By Professor Xavier Stainier. (Communicated by Dr. A. Smith Woodward, F.R.S., Pres.G.S.)

In this paper the author records the discovery of a specimen of a new *Eurypterus* in the cores of a trial boring for coal in Belgium. He describes the fossil, which is in a very satisfactory state of preservation. To allow of comparisons, a short description of the eleven Carboniferous species known up to the present is appended. The nearest form to the Belgian fossil seems to be a Pennsylvanian *Eurypterus*, which nevertheless is not identical with the former. The author then discusses the geological range and the evolution in time of the twelve Carboniferous Eurypterids. The paper ends with a short literature on the subject.

2. "On a Fossiliferous Limestone from the North Sea." By Richard Bullen Newton, F.G.S.

The material on which this paper is based was trawled from the floor of the North Sea, some 100 miles N.E. ½ N. of Buchan Ness, and was forwarded to the British Museum (Natural History) by Mr. R. D. Thomson, of Aberdeen. It presents no appearance of glaciation, so that its occurrence in situ seems to be highly probable. There is no record of a similar limestone from either England or Scotland. It is of highly siliceous character and full of marine shells, of which the Pelecypoda are the more prominent; there are, also, occasional fragments of wood in contact with the limestone which, from a preliminary examination, appear to show coniferous characters. Some twenty-three species of Mollusca have been determined, all of which exhibit a southern facies, including ten

Gastropods and thirteen Pelecypods: the latter embrace a new Dosiniform shell belonging to the genus *Sinodia*, the relationships of which are entirely confined to the Indian Ocean regions of Southern Asia. Eighteen of the species, or about 80 per cent, trace their origin from the Vindobonian stage of the Miocene; ten, or about 40 per cent, may be regarded as extinct; whereas twelve, or 50 per cent, still exist in recent seas. The majority of the species are fairly evenly distributed in both the Coralline and the Red Crag formations of East Anglia, although, on account of so large a number being extinct, and bearing in mind their southern facies, it is thought that the rock must be of older age than Red Crag. Additional support is given to this view because such shells as *Arcoperna sericea*, *Tellina benedeni*, and *Panopæa menardi* are not known of later age in this country than the Coralline Crag. The occurrence also of the extinct Gastropods *Streptochetus sexcostatus* and *Ficus* [*Pyrula*] *simplex*, which are particularly characteristic of the Upper Miocene or Messinian deposits of Northern Germany, constitutes further evidence in favour of a greater antiquity for this limestone than that of the Red Crag: it is therefore considered to be of Coralline Crag age.

3. "The Origin of the Tin-ore Deposits of the Kinta District, Perak (Federated Malay States)." By William Richard Jones, B.Sc., F.G.S.

Certain tin-ore-bearing clays and boulder-clays occurring in the Kinta District have been described by Mr. J. B. Scrivenor, Government Geologist F.M.S., as being of glacial origin, and the tin-ore which they contain as having been derived from "some mass of tin-bearing granite and rocks altered by it, distinct from and older than the Mesozoic Granite" (that is, than the granite now in situ in the Kinta District). These clays and boulder-clays are stated to have furnished a more valuable horizon on climatic evidence than can be afforded by limited collections of fossils in rocks far removed from Europe, and have been correlated with the Talchirs of India and mapped as Older Gondwana rocks.

It would be difficult to over-estimate the importance of the origin of these clays in a country where, on the one hand, they yield a very important part of the world's output of tin-ore, and where, on the other, they have been used as the horizon on which to base the geological age of rocks which cover about a third of the surface of the Malay Peninsula. If of glacial origin, a vast tin-field remains to be discovered.

The object of this paper is to show that all the tin-ore found in these clays is derived from rocks now in situ in the Kinta District; that it is not necessary to bring in glacial action to explain any of the features which led to the adoption of the theory of their glacial origin; to point out that these deposits cannot be correlated with the Talchirs of India; and to show that a simple interpretation may be given to the geology of the Kinta District.

The sources of the tin-ore here are: (1) the stanniferous granite of the Main Range and of the Kledang Range; (2) other granite outcrops known to carry cassiterite; (3) the granitic intrusions in

the phyllites and schists, notably near the granite junction; (4) the granitic intrusions traversing the limestone and forming an important source of ore.

The angularity of the boulders and of the tin-ore in some of these clays is due (1) to weathering in situ of the phyllites and schists, which then sink on the dissolving limestone underneath; (2) to soil creep effecting the same result; (3) to the breaking-up of the much weathered cassiterite-bearing boulders and pebbles in the alluvium.

Over 90 per cent of the ore worked in the whole of the Kinta District is obtained from mines situated at less than a mile from granite or from granitic intrusions.

Mineralogical Society.

June 15, 1915.—Dr. A. E. H. Tutton, F.R.S., President, in the Chair.

G. M. Davies: Detrital Andalusite in Cretaceous and Eocene Sands. Detrital andalusite is not confined to Pliocene and later deposits as was formerly supposed, but is a frequent constituent throughout the Cretaceous and Eocene beds of the South-East of England. In the Lower Cretaceous beds it is still perfectly fresh, and shows no signs of instability under the influence of meteoric water.—J. F. N. Green: The Garnets and Streaky Rocks of the English Lake District. Certain peculiar rocks occurring in the Lake District are characterized by almandine garnets and parallel streaks of secondary minerals. The capricious distribution of the garnets in diverse rock-types was considered to exclude originality, and thermal or dynamic alterations were shown to be inadequate. Circulating solutions under pressure during the solfataric stage of the Borrowdale episode were suggested as the agent, and illustrations were given of the replacement of felspar by garnet in Lake District rocks. The same origin was assigned to the streaky infiltrations which frequently contain pyrites or garnet.—Dr. S. Kôzu: On the errors in the angle of the optic axes resulting from those of the principal refractive indices determined by total reflection. The indices so found are correct within 0·0002 for sodium light. Assuming the error to be only half this, the extreme values of the angle are for anorthite 76° 8·6′ and 79° 21·8′, for albite 76° 14·1′ and 80° 46·9′, and adularia 56° 16·9′ and 65° 56·9′.—Dr. S. Kôzu: The influence of Temperature on the Optic Axial Angle of Sanidine from the Eifel. Pockels has shown that in those rhombic crystals in which the axial angle varies considerably in the neighbourhood of zero the relations between the angle and the temperature is represented by a parabola. Sanidine from the Eifel very nearly approaches the conditions of a rhombic crystal. The values of 2E were determined for seven different wave-lengths. The plotted curves were found to accord with Pockels' statement; further, the complex curves for the various wave-lengths were identical.—Dr. G. T. Prior: The Meteoric Stones of Warbreccan, Queensland. Three stones, weighing respectively about 69, 64, and 1 lb., were known to the natives of Central Queensland before 1904, and their fall was probably seen. They were acquired by the British Museum in 1905. They are white-veined chrondites, and in chemical

and mineral composition are similar to other members of the group.—A. F. Hallimond: On Autunite. It is concluded that the Cornish material is essentially different from the Autun mineral, and the name bassetite is proposed for the former, the fundamental characters of which are: oblique, $\beta = 89° 17'$; $a : b : c = 0{\cdot}3473 : 1 : 0{\cdot}3456$; forms 010, 110, 120, 011, 111, 121, $\bar{1}21$, $\bar{1}41$, $\bar{1}01$; twinning by parallel growth of *a* and *c* axes, perfect cleavage parallel to 010, also 100, 001; yellow, transparent; biaxial, $2E = 110°$; pleochroic, pale to deep yellow; soluble in acids.

CORRESPONDENCE.

THE UNDERGROUND FLOW OF THE YORKSHIRE DEE IN DENTDALE.

Sir,—On walking from Hawes Junction to Sedbergh on June 23 this year, after a prolonged period of drought, I found the bed of the Dee quite dry for many hundreds of yards. The river flows over the Great Scar Limestone, and its bed forms an interesting study. Over long stretches the bare limestone was exposed, worn to a slippery smoothness and devoid of any surface pebbles or boulders, except in the numerous cylindrical pot-holes drilled by them, some of which were as much as 10 feet in diameter. Miniature cañons have been cut through the limestone, and, as Dr. Strahan[1] remarks, "the gradient of the river-bed frequently agrees with the inclination of the strata, and in such cases the water slides for many yards over the smooth surface of the same bedding plane." At intervals waterfalls occur and the river plunges from a stratigraphically higher to a lower limestone bed. This applies more particularly to the river course between the mouth of Cowgill Beck and the seventh milestone from Sedbergh. On the other hand, long stretches occur where the solid rock of the river-bed is completely hidden under a chaos of boulders or shingle. At several points pools of water occurred owing to inflow of tributary streams or springs. These pools were in some cases without visible outlet. Where boulders filled the stream bed immediately below the pool it is, of course, possible that the overflow of the pool took place over the solid rock but beneath the boulders. In other cases the only outlet for the pools must be subterranean. At one place higher up stream than the seventh milestone an inflow of several gallons per minute joined the Dee on its left bank, gushing out from a subterranean channel.[2] Whether this water was the same as that which disappeared higher up stream or not would be difficult to ascertain without chemical tests. It seems, however, clear that some of the water of the Dee follows a subterranean course, though it does not necessarily follow that it rejoins the river lower down. The underground course of the Dale Beck near Ingleborough is well known, but, so far as I know, that of the Dee has not been previously mentioned.

B. Hobson.

[1] *Geology of Country around Ingleborough* (Mem. Geol. Surv.), 1890, p. 42.
[2] I have since seen an underground inflow on the right bank above Lea Yeat.

MISCELLANEOUS.

Geologists' Association Excursion to the London Area.—Subject to possible interruption the Council has wisely arranged that the usual Long Excursion shall be held in the London area between August 25 and September 5. This has for long been suggested as affording an inexpensive and agreeable excursion for provincial members. The proceedings may commence with an evening meeting, at which a general sketch of the geology of the London district will be given, with special references to the places to be visited. Excursions, arranged for eight or ten days, will comprise field-work in the following formations: Lower Greensand (Hythe Beds and Folkestone Beds), Gault, Chalk, Thanet Sand, Woolwich and Reading Beds, Blackheath and Oldhaven Beds, London Clay and Bagshot Beds, Pleistocene deposits (Glacial Drift and River Drift), and gravels of various ages. As opportunities arise attention will be directed to the casual connexions between the geology and geography of the various localities. It is hoped that the series of excursions will form a fairly complete demonstration of the field geology and geography of the London district. Those localities marked with an asterisk will have first consideration. **Charlton*, Chalk and Lower London Tertiaries; **Crayford and Dartford Heath*, River Drift, gravels, and brick-earths, Palæolithic sites; **Dorking*, the Chalk Escarpment and the Gorge of the Mole; *Edmonton*, Lea Valley gravels, Late Arctic deposits; **Erith*, Lower London Tertiaries for comparison with Charlton; **Godstone*, Upper Greensand, hearthstone excavations, Lower Greensand, Folkestone Beds; *Grays*, Chalk, whitening and cement works, river gravels, and brick-earths; *Guildford*, Lower Cretaceous rocks, Chalk, geographical features; **Harefield*, solution phenomena illustrated by 'pipes' in the Chalk; **Herne Bay*, continuous section of Lower London Tertiaries (Thanet, Woolwich, and Oldhaven Beds) and London Clay for comparison with the sections in the London area; **Hertford and Hertingfordbury*, Glacial Drift; **Leatherhead*, the Chalk Escarpment, Vale of Holmesdale, and the Valley of the Mole; **North Downs*, Guildford, Leatherhead, Worm's Heath, and Tandridge Hill, at the two latter places outliers of Blackheath Beds, 'pipes,' and other solution phenomena; *Otford*, chalky rainwash, Gault, and the Gorge of the Darent; **Ponders End*, gravels in the Lea Valley; **Potters Bar*, swallow-holes; *Reigate*, Lower Greensand and Chalk; **Reading and Wokingham*, Reading Beds and London Clay; *St. George's Hill*, Bagshot Beds; *St. Albans*, Boulder-clay and Glacial Gravels; **Well Hill*, outliers of Woolwich and Blackheath Beds, dry valley gravel and hill gravel, swallow-holes. All members, but particularly those living in the provinces, who contemplate joining these excursions, are requested to send their names to the Secretary immediately.

Geological Survey of the Union of South Africa.—Mr. H. Kynaston, B.A., F.G.S., Director of the Geological Survey of the Union of South Africa, Pretoria, writes, under date May 10, 1915, stating there will be no Annual Report of this Survey issued for the year 1914.